84- 4542 /

South Saskatchewan River Basin Planning Program

Water Resources

Water Resources Management Services
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July, 1984

ERRATA

On the Scenario Key, under "Water Quantity/Quality Conditions," paragraph 5, line 4, the sentence should read:

The remaining clusters below the cities have two columns: the left-hand column illustrates water quality conditions with secondary sewage treatment in each major city; the right-hand column illustrates water quality conditions with advanced sewage treatment in each major city.

On page 17, column 2, paragraph 3, line 26, the sentence should read:

Periods of three or more years of below-average flows occurred in 1929 to 1941, 1943 to 1946, 1961 to 1964 and 1976 to 1979.

On page 18, column 1, line 22, the sentence should read:

The historic record reveals that the 24, 30 and 36 months of lowest flow on each of the Bow, Oldman and South Saskatchewan rivers occurred during the period from September 1938 to April 1942.

On page 29, column 3, line 3, the sentence should read:

Thus, in a perfectly designed and operated system, with a minimum of opportunity for evaporation or seepage, the amount of water delivered to a district would approximate the crop water requirements of farms served by the district, and the water use efficiency would, in theory, approach 100%.

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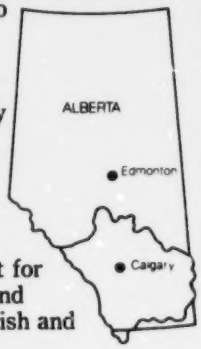
Introduction

The South Saskatchewan River System has had a profound influence on human settlement and economic activity in southern Alberta. From the early days of this century, the water in these rivers has been used to support irrigation which has served as an impetus to settlement, as a hedge against recurring droughts, and as a means for increasing agricultural production and both farm and off-farm incomes. It has been used to produce electrical energy, and for everyday household and municipal uses. It has provided an environment for recreation and habitat for fish and wildlife.



Today, the water in this river system continues to play a vital role in irrigating a million acres of land, generating 1000 gigawatts of electricity annually, supplying the domestic needs of a population of over one million people, serving industry, and providing sport fishing and recreation opportunities for basin residents and for tourists from other parts of the province, the nation and the world.

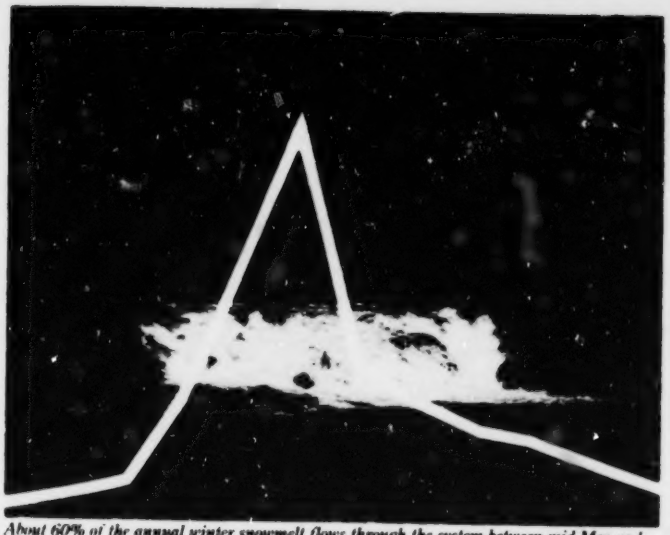
The benefits from this river system have not been Alberta's alone. The water in the river system flows eastward into Saskatchewan where it becomes part of the larger Saskatchewan-Nelson river system draining into Hudson Bay. An agreement with the other prairie provinces and the federal government allows Alberta to consume 50% of the natural flow volume of the South Saskatchewan each year. The remainder must be passed on to Saskatchewan.

The major rivers of this system, the Red Deer, the Bow, the Oldman, and their principal tributaries rise in the front range of the Rocky Mountains where most of the water in the system originates as meltwater from the winter snow-pack. Because of this, the streamflow in the system varies markedly, both annually, depending upon the amount of winter snowfall in the mountains, and seasonally – about 60% of the annual mountain snowmelt flows through the system in the two months from mid-May to mid-July. Over the years, there have been investments in dams to store water and regulate the streamflow, canals to deliver water to users, and treatment plants to reduce the flow of

Fig. 1.1
South Saskatchewan River Basin

contaminants to the river system. At the same time, however, water consumption, chiefly in irrigation, and waste loadings from the larger urban centres have increased, so that inadequate water supply and poor water quality continue to pose problems. Over the past 15 years, Alberta has passed, on an average, **83%** of the natural flow of the river system on to Saskatchewan each year, rather than the minimum **50%** required. This indicates that our current problems are a consequence of periodic seasonal imbalances in the supply and use of water, rather than of an overall shortage of water, and can be remedied by increased storage and sewage treatment and more intensive management of the regulation and use of the water in the system.

Looking to the future, even modest increases in irrigation and urban populations will require more costly works and intensified management of the supply, use and quality of the water in the river system if we are to continue to serve the diversity of uses that depend on this resource.



About 60% of the annual winter snowmelt flows through the system between mid-May and mid-July.

The relationship between the rivers in the South Saskatchewan River system and the conditions of the Master Agreement on Apportionment mean that we cannot manage any one river in isolation from the others. We must consider how decisions about the use and management of water in one basin will affect the use and management in the other two basins. This understanding was expressed by Alberta Environment in a 1976 management statement concerning development on the Red Deer River:

"To honour this commitment (to provide a specified flow to Saskatchewan) while at the same time ensuring the most beneficial use of the water to which Alberta is entitled, the flow of the major tributaries to the South Saskatchewan River – the Bow, the Oldman and the Red Deer – must be managed equitably and in concert."

The planning program described in this report is designed to provide a framework plan for the management of water to meet these needs. The South Saskatchewan River Basin Planning Program is being conducted in two phases. The first, or strategic planning phase, the basis for this report, will result in the development of a strategy for the use and management of water in the basin. The program will identify the objectives to be achieved through water use and management, and establish, from among a number of options, the most appropriate water use and management strategy for contributing to the achievement of those objectives. The second, or framework planning phase, will set out specific ways and means for managing water to achieve the objectives, consistent with the strategy.

The information that has been obtained and analyzed in the strategic planning phase, and which is the subject of this report, provides a basis for consideration of three major policy questions:

1. How is the supply of water to be allocated among uses?
2. What are the priorities among the options for water management?
3. How much water will each of the three major rivers contribute to apportionment?

The answers to these questions will become the foundation of a water use and management strategy for the South Saskatchewan River Basin.

These are important questions for the future of southern Alberta. Policy in these areas has significant implications for future investment decisions by farmers, irrigation districts, industry and governments at the provincial and municipal levels. Decisions about how much water in a river system can be allocated for consumptive uses will have implications for regional development. Decisions about fish habitat, water quality and management options will play a large part in shaping the future environment of southern Alberta.

Establishing policy in these areas means that some values and goals may have to be foregone in order to achieve others felt to be more important. Some examples of the trade-offs that will have to be considered include limiting the allocation of water to irrigation in order to maintain a viable sports

The South Saskatchewan River System supplies water to over one million people in southern Alberta.

fishery; spending more on sewage treatment so that more water can be withdrawn from our rivers for irrigation; sacrificing a reach of river and valley land with value for recreation, agriculture or wildlife habitat in order to develop a reservoir to store water and regulate streamflow for irrigation, fish habitat and water quality protection; limiting water-dependent development in one region in favour of another.

The purpose of this report is to present information that will aid the people and the elected decision-makers of the province in considering policy and strategy options. The opening chapter describes the physical and cultural character of the basin and presents information about water use and management from both a contemporary and a historical perspective. A chapter is devoted to economic and social objectives and government policy and their relationship to a strategy for water use and management. The final chapters include a summary of a number of "scenarios" that illustrate a range of strategy options and an explanation of how these were developed, analyzed and evaluated.

2

The South Saskatchewan River Basin

The Red Deer, Bow, and Oldman rivers rise in the mountains and foothills in the western portion of the basin. Along with the South Saskatchewan River, formed at the confluence of the Bow and Oldman rivers, these rivers form the South Saskatchewan River Basin. About 75% of the annual streamflow of these rivers originates as snowmelt in the mountain and foothills region. As the rivers flow eastward, they drain an area of about 46,000 square miles (120,000 sq. km), approximately one-fifth of the total land area of Alberta.

The Red Deer sub-basin accounts for 41% of the area of the South Saskatchewan basin; the Bow, 21%; the Oldman, 22%; and the South Saskatchewan, 16%. Although the Red Deer River does not join the other rivers until they have passed into Saskatchewan, the Master Agreement on Apportionment allows Alberta to include the flow of the Red Deer with the flows of the other rivers for calculating apportionment.

There are few natural lakes of any size in the basin; Sylvan, Gull, and Buffalo lakes in the northern Red Deer basin are the most prominent. Each of these lakes is in a small internal drainage basin apart from the major river system. They generally do not contribute to or extract significantly from the flows in the South Saskatchewan River system.

There are a number of small to medium-sized reservoirs located on the main river system, or that are supplied from canals that divert water from the river system. The more prominent natural lakes and storage reservoirs are shown on the map accompanying this report (in folder).

The geography of the land in the basin is as different as the rivers which cross it. Elevations range from 4000 to 6000 feet (1200 to 2000 m) above sea level in the mountains where the rivers begin, to about 2000 feet (600 m) above sea level in the east.

Fig. 2.1
Agro-climatic zones in the South Saskatchewan River Basin

The western portion of the basin is characterized by coniferous forest in the mountains, and mixed forest and open grasslands in the foothills. Further east, the northern portion of the Red Deer basin lies in the parkland zone where mixed aspen, poplar and grasslands predominate, while the remainder of the prairie region is relatively flat and extensively cultivated.

Soil types in the basin vary. Black to grey-wooded soils characterize the cultivated areas in the west, and black soils are found in the area in the Red Deer basin. Soil types found in the remaining prairie region vary from black on the western fringe through dark brown at the eastern border.

There are variances in the amounts of precipitation which fall in the various regions as well. In the western-most mountain and foothills region, some 20 to 24 inches (500 to 600 mm) of precipitation are received annually, mostly in the form of winter snowfall. In the southern prairie region, precipitation ranges from 18 inches (450 mm) in the west to less than 12 inches (300 mm) in the east.

There are fewer than 100 frost-free days in the western and northern regions, and between 100 and 200 frost-free days in the southern region.

The variety in vegetation, soil, climate, and precipitation, and ultimately, the water supply in the rivers, lakes, and streams in the basin all have an impact on what happens in the basin. They determine what kinds of agriculture take place, how industry develops, the size and location of towns and cities, and the potential for tourism and recreation. In the South Saskatchewan River Basin, the way we manage water affects almost every aspect of our lives.

Agriculture

Agriculture in the South Saskatchewan basin is the predominant activity in the plains region, not including the activity of large urban centres, and occupies 75% of the land in the basin.

Alberta Agriculture has identified five agro-climatic zones within the South Saskatchewan River Basin, based on variance of heat units, length of growing season and the deficit from the natural moisture required for maximum crop production. These zones, which are indicated in Figure 2.1, have particular significance for the practice of irrigation, and figure prominently in the analyses undertaken in this planning program.

Zone A_1 is located in the southeast portion of the basin. It receives the most heat units and has the longest growing season, but is driest (has the greatest moisture deficit). Zones A_2 and B receive the same number of heat units and have the same length growing season, but Zone A_2, lying farther to the north and east, is drier than Zone B. Zone C, lying farther to the west and at higher elevations, has the same length of growing season as do zones A_2 and B, but receives fewer heat units and receives more moisture than those zones. Zone D, which encompasses the foothills and parkland portions of the basin has the least moisture deficit, but also experiences the fewest heat units and has the shortest growing season of the five zones. There is very little irrigation practiced in Zone D; the combined effects of its short growing season, limited heat units, slight moisture deficit, and the soils and topography characteristic of this region, limit the prospects of any extensive irrigation in this zone in the future.

In the basin, two agricultural methods of growing crops are practiced: dryland farming and irrigated agriculture.

Cropping patterns are very different for dryland and irrigated agriculture. (See Fig. 2.2) While the greatest percentage of the irrigated cropland is dedicated to the production of cereal grains at 54%, 89% of dryland farming is seeded to cereal grains. Alfalfa, hay and fodder are grown on 31% of the irrigated cropland, but on only 7% of the dryland acreage. Specialty crops are grown on 11% of the irrigated cropland, while no specialty crops are grown on dryland.

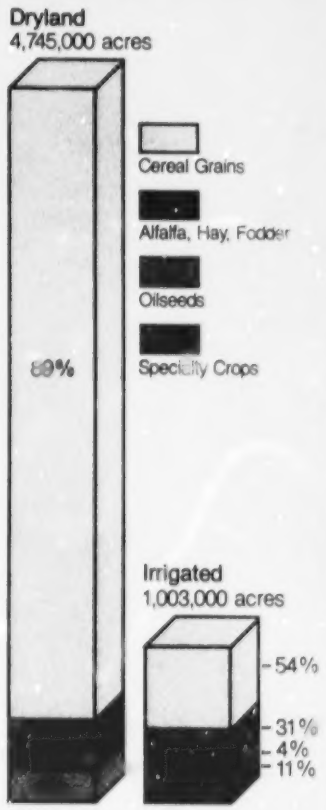


Fig. 2.2
Dryland and Irrigated Cropping Patterns for Zones A1, A2, B and C (1980)

Zone	Characteristics
A1	1650 Heat Units 140 Day Growing Season 250-300 mm Moisture Deficit
A2	1350-1650 Heat Units 120-140 Day Growing Season 250-300 mm Moisture Deficit
B	1350-1650 Heat Units 120-140 Day Growing Season 200-250 mm Moisture Deficit
C	1150-1350 Heat Units 120-140 Day Growing Season 150-250 mm Moisture Deficit
D	1200 Heat Units 120 Day Growing Season 150 mm Moisture Deficit
	Not Rated

Irrigation

Irrigation has become increasingly important both as an alternative and as a supplement to dryland farming in the basin. It is currently the largest consumptive user of water in the basin.

In 1981, 5800 of the 11,000 farms in the four agro-climatic zones in the basin used irrigation served by 12 major irrigation districts. 13 including the Ross Creek Irrigation District south of Medicine Hat which serves only nine farms. Of the total area of cultivated land (5,750,000 acres or 2,330,000 hectares), the irrigated land accounts for 17% or about 1,000,000 acres. The irrigated areas generate an estimated 18% of the gross value of agricultural production in the entire province.

Figures 2.3 and 2.4 show the distribution of irrigation districts and irrigated cropland in relation to the four agro-climatic zones. Most of the irrigated cropland in the basin is located in zones A_1 and A_2. About one-third of the total cropland in these two zones is irrigated, reflecting the severe moisture deficits experienced in southeastern Alberta. Following this pattern, 90% of the irrigated cropland devoted to specialty crops is in zones A_1 and A_2 – 52% in Zone A_1, which receives the most heat units and has the longest growing season. Alfalfa and pasture are important crops in Zone A_2 which has 54% of the irrigated alfalfa and pasture cropland in the basin and 33% of the basin's livestock population. In Zone C, which has about 40% of the livestock population of the basin, pasture and alfalfa crops account for 60% of the irrigated cropland. Over one-half of the province's beef cattle are produced in the South Saskatchewan River Basin.

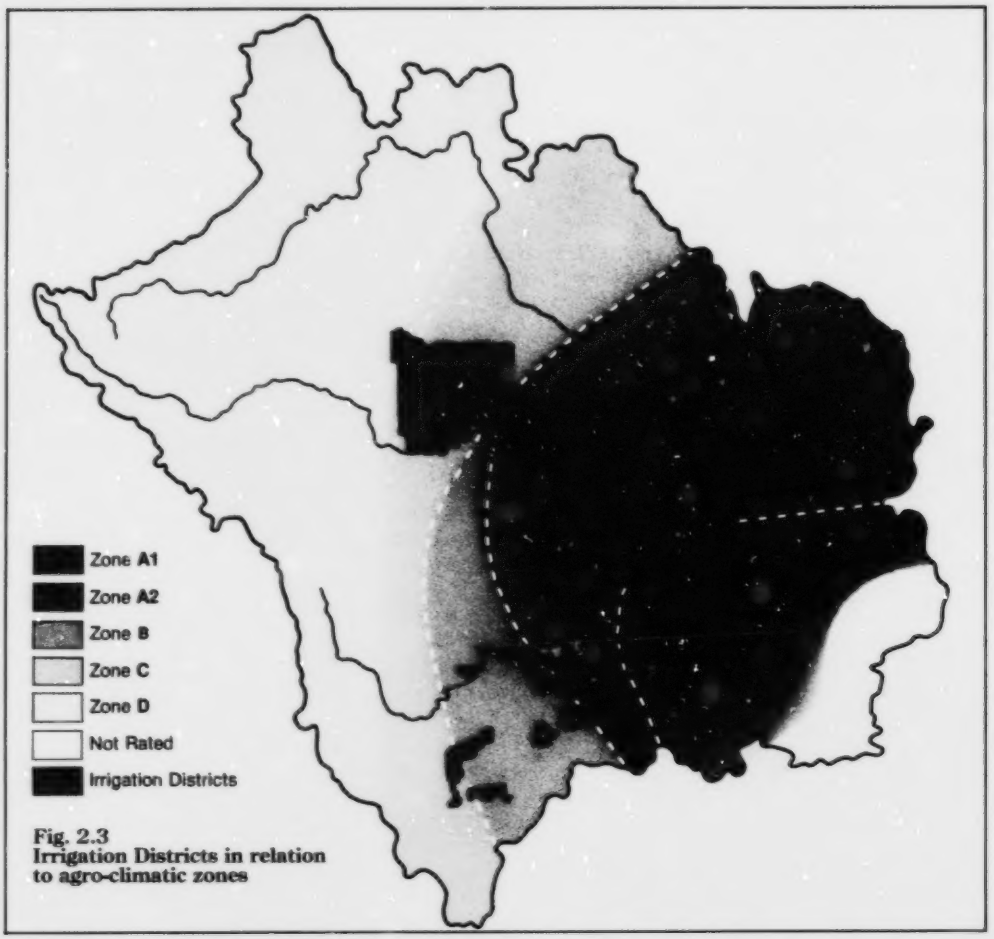


Fig. 2.3
Irrigation Districts in relation to agro-climatic zones

Not all of the irrigated cropland is in the same sub-basin as the river system from which the land is supplied with water. For example, only 58% of the land irrigated with water from the Bow River system is situated in the Bow River sub-basin; 28% is in the Red Deer, and 14% in the Oldman sub-basins. Similarly, 65% of the land irrigated from the Oldman River system lies in the Oldman sub-basin; the remaining 35% is in the South Saskatchewan sub-basin.

The significance of irrigation to livestock and crop production in the basin today has historical roots that date back to the late 1800's when it supported the earliest settlement and economic activity.

In 1894 the Dominion government passed the Northwest Irrigation Act, which gave the Crown absolute ownership and control over the development and use of all water in the basin. The intent of this legislation was to facilitate the orderly development of irrigation to assist the agricultural settlement of the western prairies – a critical aspect of the national policy of the Dominion government of that period. Along with other legislation and policy pertaining to the acquisition of land, this Act ushered in a period of corporate development of irrigation. The Canadian Pacific Railway, the Alberta Railway and Irrigation Co. (eventually controlled by the CPR) and the Canada Land and Irrigation Company initiated large-scale irrigation projects and works to divert and deliver water to company-owned land in the Lethbridge, Brooks and Calgary areas. The land was sold to settlers, but the companies retained ownership and control of the works for delivery of water. By 1920, about 180,000 acres (72,000 ha) of land was being irrigated in the basin.

A number of irrigation districts had been established under the Alberta Irrigation Districts Act of 1915. With the establishment of the new districts, the amount of irrigated land increased by 160,000 acres (64,000 ha) between 1920 and 1930.

From the early 1920's to the mid-1940's, corporate dominance in the development of water and irrigation gave way to direct government involvement in both the development of water and the management of irrigation districts. As this transition took place, the Canadian Pacific Railway's interests were transferred to the Western Irrigation District (WID) and the Eastern Irrigation District (EID). Both provincial and federal governments chose to provide assistance to the operations of some districts and corporate projects ravaged by the depression and drought of the 1930's. During these years, the spread of irrigation farming slowed, increasing by only 70,000 acres (28,000 ha) between 1930 and 1940, and by 40,000 acres (16,000 ha) between 1940 and 1950.

Active government involvement began in 1946 when the interests and obligations of the Alberta Railway and Irrigation Co. were transferred to a provincial crown corporation established to administer the St. Mary and Milk River development. In 1950 the federal government purchased the holdings of the Canada Land and Irrigation Co., and in co-operation with the province, rehabilitated and expanded irrigation in the Bow River Irrigation Project (the present-day Bow River Irrigation District). During the 1950's the federal government built the Travers reservoir and enlarged the McGregor and Little Bow reservoirs for the Bow River project, and the federal and provincial governments collaborated in the development of the St. Mary project, including construction of the Waterton, St. Mary and Ridge reservoirs, and the canal system for the diversion and delivery of water. Between 1950 and 1960, the

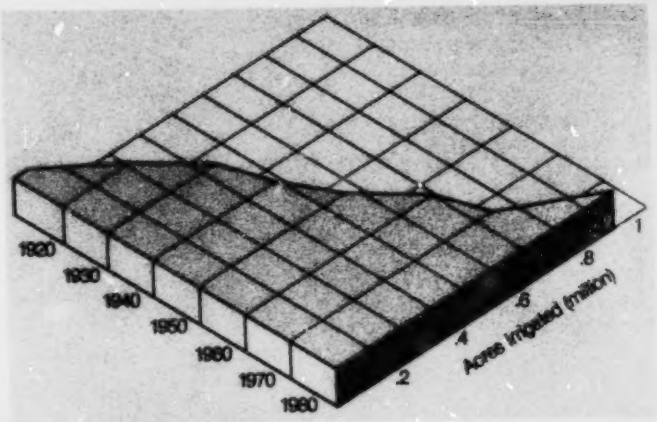


Fig. 2.5 Historical growth of irrigation in the South Saskatchewan River Basin (1910 - 1980)

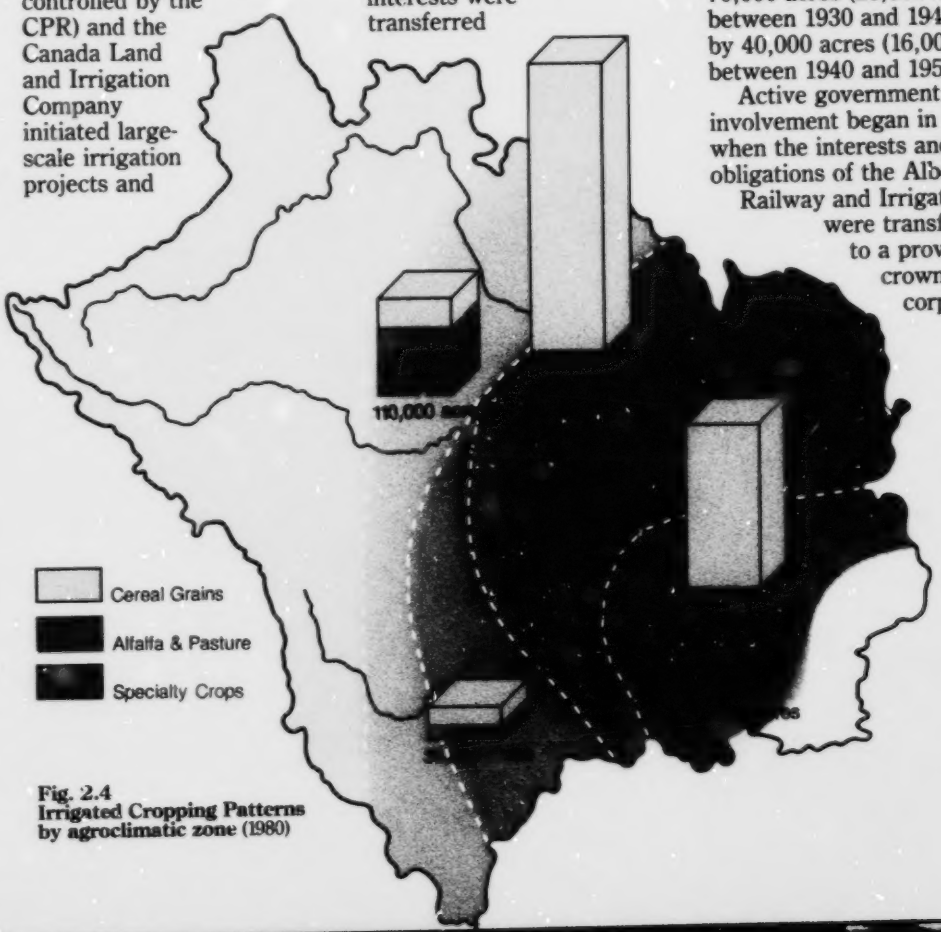


Fig. 2.4
Irrigated Cropping Patterns by agroclimatic zone (1980)

area irrigated by irrigation districts and government projects increased by 150,000 acres (60,000 ha), tapering off to an increase of 40,000 acres (16,000 ha) between 1960 and 1970.

In 1968, Alberta passed the Irrigation Act, which brought all irrigation districts under uniform legislation. The government initiated a number of programs directed at bringing stability to the large-scale irrigation developments that had evolved in the basin. In 1970, a cost-sharing program to assist irrigation districts in financing the rehabilitation of their water storage and delivery systems was introduced. In 1973, the province and the federal government signed an agreement which saw the federal government withdraw from active involvement in the management of water and irrigation in the basin. The province, through the Department of Environment, assumed ownership and operational responsibility for all of the federal irrigation systems, and such major works as the WID weir, the Carseland weir, and the EID aquaduct were rehabilitated. In 1975, the province introduced a new 10-year program for rehabilitating headworks and sharing the costs of rehabilitating district works. During the years between 1970 and 1980, sprinkler irrigation systems were introduced widely, which reduced farm labour costs and brought irrigation to land that previously had been impractical to irrigate with other methods. As indicated in Figure 2.5, the 240,000 acre (96,000 ha) increase in the amount of land irrigated by irrigation districts in the period 1970-1980 was the most substantial increase in any decade since irrigation began in the basin.

Photo courtesy of Glenbow Alberta Institute

Irrigation system and gate lock, Lethbridge (c. 1912)

Photo courtesy of Glenbow Alberta Institute

Kananaskis Falls hydro development project, Kananaskis (c. 1911)

Hydro

The use of water to generate hydroelectric power in the basin has roots that go back almost as far as those of irrigation.

The development of the basin's water resources to generate electricity began in the 1890's when the Calgary Water Power Co. installed a 780-horsepower generating plant on the Eau Claire Lumber Co. canal off the Bow River in Calgary.

With the exception of the original Cascade plant, TransAlta Utilities Corporation (formerly Calgary Power Ltd.) has been responsible for all subsequent water development for hydroelectrical generation in the basin, and all of that development has been on the upper reaches of the Bow River system. Beginning with the Horseshoe Falls plant in 1911, TransAlta developed the Kananaskis Falls and Ghost River plants on the Bow River, and developed storage reservoirs at Lake Minnewanka, upper Kananaskis Lake and the Ghost site on the Bow River prior to World War II.

During the war years, a plant was built at Cascade, the Ghost River diversion to Lake Minnewanka was completed, and storage at Lake Minnewanka and Upper Kananaskis was expanded.

The most active period of hydro development in the basin occurred during the post-war expansion period when storage reservoirs

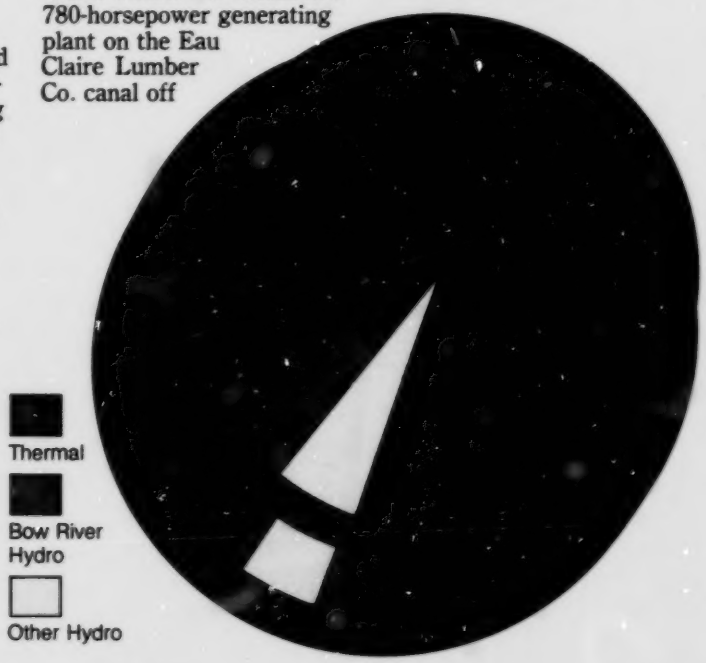


Fig. 2.7
Generating Capability, Alberta Electrical Utilities

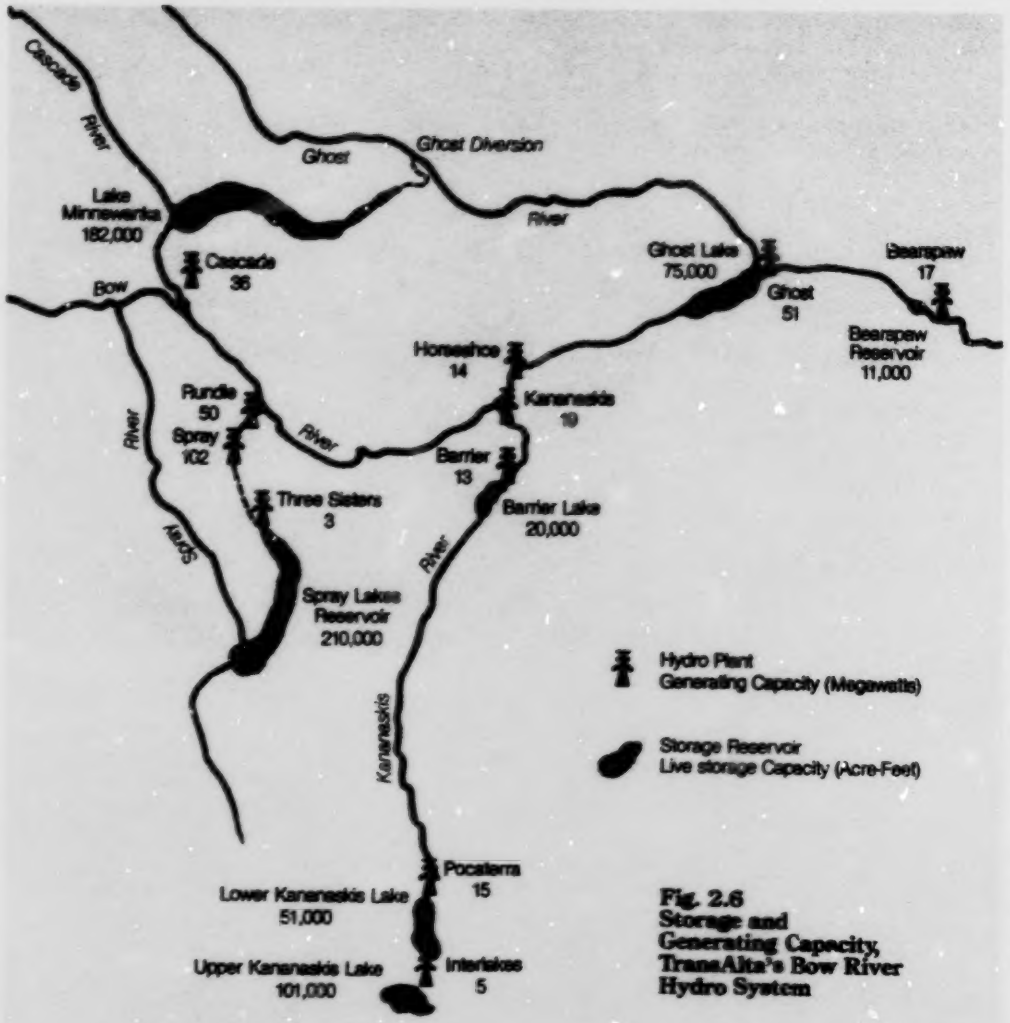


Fig. 2.6 Storage and Generating Capacity, TransAlta's Bow River Hydro System

were developed at Lower Kananaskis, Barrier Lake, Spray Lake and at the Bearspaw site on the Bow River, and the Barrier, Spray, Three Sisters, Rundle, Pocaterra, Interlakes and Bearspaw plants were built. During this same period the Cascade, Ghost and Kananaskis plants were extended to their present capability. The last hydro developments on the Bow River system were in 1960 when the Spray and Rundle plants were extended to their present capability.

Today, TransAlta Utilities owns and operates 11 hydro-electric generating plants in the upper reaches of the Bow River system with a generating capability of 325 megawatts. These plants account for about 10% of TransAlta's total capability. Information pertaining to the particular plants and associated storage reservoirs in the Bow River hydro system is provided in Figure 2.6

Almost all of the electricity generated by electrical utilities in Alberta is distributed through the Alberta Interconnected System (AIS). The Bow River hydro plants represent 6% of the total generating capability of Alberta utilities, and in 1981 they generated about 5% of the total electrical energy distributed through the AIS. When the additional plants approved by the Energy Resources Conservation Board come on stream by 1990, the Bow River hydro plants will provide only about 4% of the peak generating capability of Alberta Utilities. (See Figure 2.7.)

These statistics tend to understate the importance of the Bow River hydro system to TransAlta Utilities and the AIS. In addition to generating sufficient electricity to meet the continuous demand or base load for electricity, an electrical system must also

be able to satisfy daily peak loads, respond to instantaneous variations in load, control voltage, and maintain reserve generating capability for regular operations such as the shutdown of a plant for routine maintenance, and the emergencies such as a plant breakdown. Because of their flexibility, hydro plants are best-suited to supply these needs.

The Bow River hydro system accounts for about 40% of the hydroelectric generating capability available to the AIS. In addition to generating base load electricity, the system is normally operated to provide spinning reserve to handle instantaneous variation in load on the AIS, to meet the peaking requirements of the Calgary area, and to provide some of the operating reserve in the AIS.

Industry

Although southern Alberta is not generally considered to be a highly industrialized region, primary resource extraction and manufacturing are fairly extensive and employ about 25% of the work force in the basin.

Oil and gas fields are particularly extensive in the eastern portions of the Red Deer and Bow sub-basins and in the South Saskatchewan sub-basin. Most of the gas processing plants in the province are in the western part of the Bow and Red Deer sub-basins. Many of these plants also extract sulphur from sour natural gas. There are also two oil refineries and an asphalt plant in this region. Despite the extensive coal reserves there are few active coal mines in the basin. Limestone is quarried in the upper reaches of the Bow basin and plants producing lime and cement are located in that area. Clays and bentonite are quarried in the eastern part of the South Saskatchewan sub-basin and plants manufacturing bricks, pottery and glass are located around Medicine Hat.

Almost all of the meagre timber resources of the basin are within the crown-owned Bow-Crow Forest in the headwaters region of the basin where a few small commercial timber operations are located.

Plants manufacturing agricultural and industrial chemicals are located in the Bow, Red Deer and South Saskatchewan sub-basins, mainly in and around Calgary, Red Deer and Medicine Hat. The food processing industry is active in all sub-basins, but particularly in the Bow and Oldman with establishments concentrated in and around Lethbridge and Calgary. While these are the most prominent manufacturing

Petrochemical plant near Red Deer

industries, there are about 1100 manufacturing operations in the basin, almost one-half of the provincial total. They account for about 45% of the provincial totals for employment, value added, and value of shipments in manufacturing. Manufacturing is very much an urban activity. Calgary, Lethbridge, Red Deer and Medicine Hat account for about 80% of establishments, employees, value added, and value of shipments. Calgary alone accounts for 60% to 65% of the basin totals in these categories. (See Fig. 2.8)

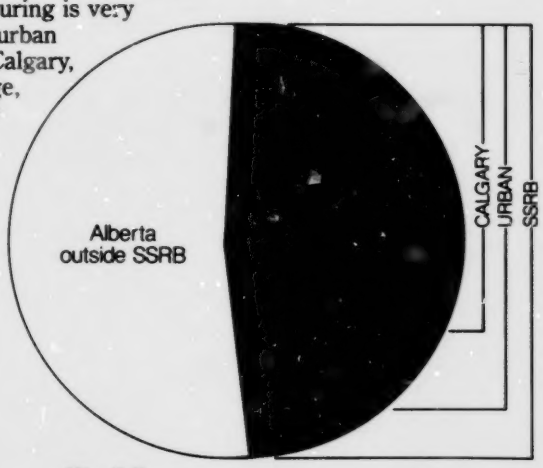


Fig. 2.8
Manufacturing in Alberta (1980)

Marina at Little Bow Provincial Park, Travers Reservoir

Aspen Beach Provincial Park, Gull Lake

Tourism and Outdoor Recreation

The tourism industry is an important and growing source of revenue for Alberta. While direct links between tourism and water are difficult to identify, about 25% of visitors to the basin (including Albertans) took part in water-based recreation such as swimming, boating, fishing, sailing, or water-skiing.

Most water-based recreation takes place on Sylvan, Gull, Buffalo and Pine lakes in the northern part of the Red Deer subbasin and on rivers and streams in the mountains and foothills within 100 km of the major urban centres. These areas, particularly those in the Red Deer subbasin, are used extensively by residents outside the basin. There are far fewer water-based recreation sites in the plains region, and they are more widely dispersed.

Outdoor recreation in general is one of the major activities in the mountain and foothills region of the basin. Kananaskis Country in the Rocky Mountain Forest Reserve in the upper Bow basin is currently the focus of extensive recreational development by the provincial government. Many of the events to be featured in the 1988 Winter Olympics will be staged at sites in Kananaskis Country, and the facilities will continue to be used for recreation by the public following the games.

Other recreational facilities in the basin include two national parks, Banff National Park and Waterton National Park, and 27 provincial parks.

Most of the provincial parks are located near water, and most offer opportunities for some form of water-based recreation. Areas adjoining a number of the irrigation headworks and canal systems have been developed for day use and the reservoirs are used for water-based recreation. In addition, there are over 200 cottage developments, private camps operated by churches or service organizations, provincial and private campgrounds, recreation areas, urban parks and private clubs devoted to particular activities using the rivers, lakes and reservoirs throughout the region.

Fisheries

Figure 2.9 illustrates the three fish habitat zones in the South Saskatchewan system. The cold water zones in the upper reaches of the system are inhabited by Mountain Whitefish, Dolly Varden and various species of trout (Brook, Brown, Cutthroat, Golden, Lake and Rainbow). The hydro reservoirs in the cold water zone support these same species, however productivity in these reservoirs is low due to fluctuations in water levels. The warm water zones in the slower flowing downstream reaches are inhabited by Northern Pike, Goldeye, Mooneye, Sauger, Walleye, and in the South Saskatchewan, Lake Sturgeon. The transition zone between the cold water and warm water zones provides habitat for some species of both warm water and cold water fish, principally Mountain Whitefish, Lake Whitefish, Pike and Walleye. The irrigation reservoirs in these zones on the Bow and Oldman support Lake Whitefish, Northern Pike and Walleye, and many are regularly stocked with Rainbow Trout for sport fishing.

The most productive river reaches for fish are on the Bow River between Calgary and the Carseland weir where the river is rich with nutrients from Calgary's sewage effluent; the cold water zone in the upper reaches of the Oldman River where flows are fairly constant and food is abundant; and on the South Saskatchewan River downstream from the confluence of the Bow and Oldman.

Sports fishing in the waters of the South Saskatchewan system is a popular pastime for many residents of the basin. Almost 300,000 angling licences are sold in the province annually, and about 40% of these are purchased by residents of the South Saskatchewan River Basin. Of those persons who fish the South Saskatchewan system, 95% are basin residents.

Fishing on the Bow River near Banff

Indications from recent surveys are that anglers generally fish within 90 miles (150 km) of home, and that on the average, each angler devotes about 10 days a year to fishing.

The river reaches most heavily used by anglers are on the Red Deer River between Sundre and Red Deer, where there is an abundance and diversity of fish and access is good; on the Bow between Calgary and the Blackfoot Indian Reserve, which is an internationally recognized trout fishery; and the Oldman River above Brocket, which is highly productive of game fish and easily accessible.

Commercial fishing, mainly for Lake Whitefish, occurs on most of the larger irrigation reservoirs in the middle reaches of the Bow and Oldman basins. In recent years, the annual catch of 300,000 to 400,000 pounds (150,000 to 190,000 kg) by the 200 licenced commercial fishermen who fish these reservoirs has accounted for

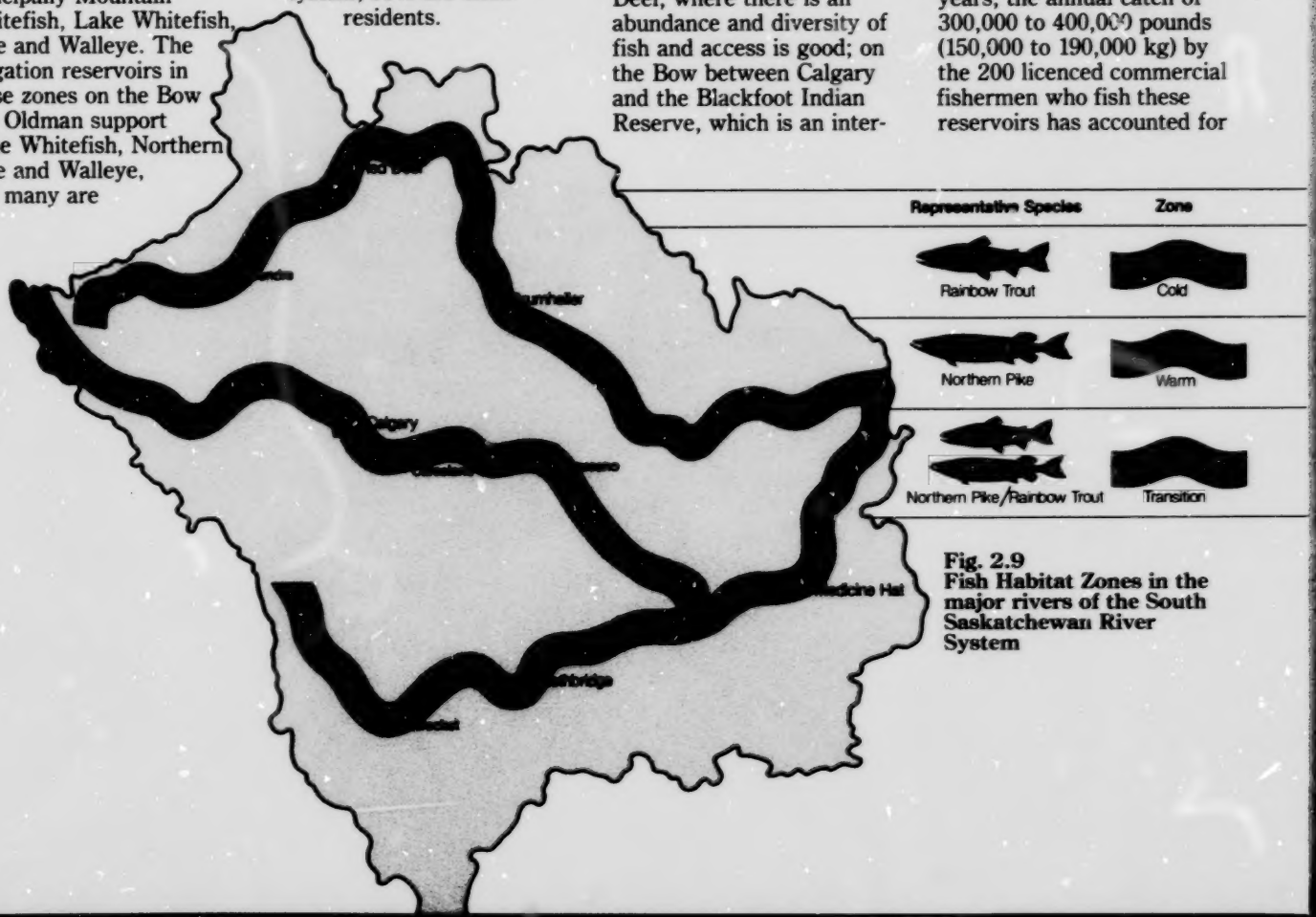


Fig. 2.9
Fish Habitat Zones in the major rivers of the South Saskatchewan River System

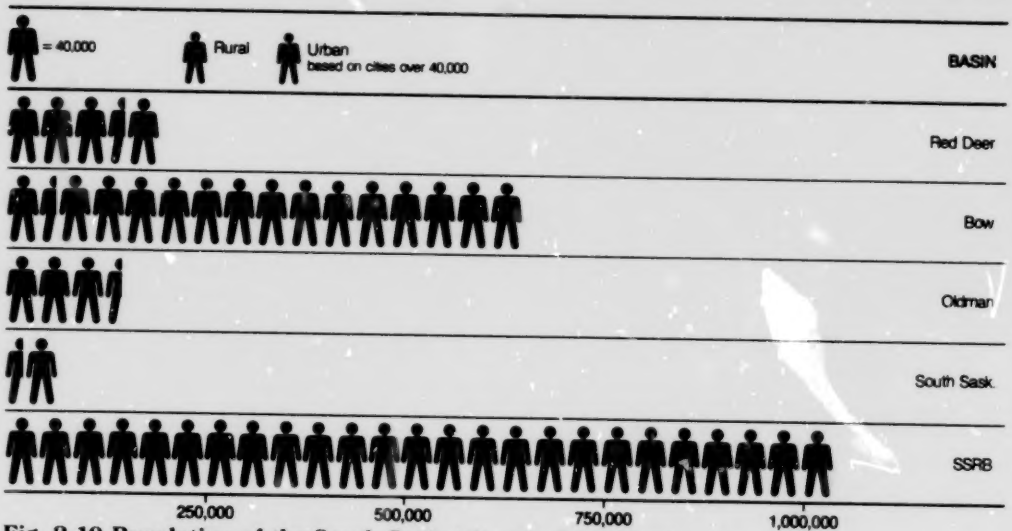


Fig. 2.10 Population of the South Saskatchewan River Basin

about 10% of both the harvest and the market value of commercially caught fish in the province.

Municipal Water Use

The municipal demand for water is related very closely to the size of the population. While the amount of water that municipalities use and do not return to the system is small compared to irrigation, the quality of the water that is returned to the rivers is affected. The need for effective sewage treatment has grown along with the population.

To examine population in the basin briefly, about 1,040,000 people or 46% of Alberta residents, live in the South Saskatchewan River Basin. The four urban centres having populations of more than 40,000 people, Calgary, Lethbridge, Red Deer and Medicine Hat, account for 71% of the population in the basin. The population of the basin is concentrated most heavily in a corridor 50 to 75 miles wide, running through Red Deer, Calgary and Lethbridge. Of the total population, 87% reside in this corridor, including 95% of the urban population and 40% of the rural population. The city of Calgary alone accounts for 81% of the urban population in the basin. (See Fig. 2.10)

Calgary's first water supply system was built in 1889, taking water from the Bow River. This supply was supplemented from the Elbow River beginning in 1907. The Glenmore Dam was built on the Elbow River in 1932, and the Glenmore water plant began supplying water to the city from this source in 1933. The capacity of this plant was expanded over the years, reaching its present capacity in 1967. In 1973 the Bearspaw water plant on the Bow River went into full production, and was expanded to its present capacity in 1978. The Bow River now provides about 50% of Calgary's municipal water supply. The other urban centres, Red Deer, Lethbridge and Medicine Hat, obtain their municipal water supplies from the Red Deer, Oldman and South Saskatchewan rivers respectively.

The larger urban centres have the longest history of disposing of their sewage effluent directly into rivers, and were among the first communities to implement primary sewage treatment. Calgary installed its first sewage treatment plant in 1932. Most rural communities installed primary sewage treatment plants at the same time that they provided municipal water supplies. All rural communities now have at least secondary sewage treatment. In 1983, Calgary introduced advanced phosphorous removal at both of its sewage treatment plants.

Most rural communities originally obtained their municipal water supplies from wells. However, as populations have grown and municipal water supply systems have been modernized, many communities have begun to obtain their water from more plentiful surface sources. Today, about 65 rural communities in the basin obtain their water from surface supplies; about one-half of these communities are supplied through the works of irrigation districts.

Over the past decade, a number of rural communities have arranged to have their treated sewage effluent used for irrigation rather than releasing it into rivers or creeks. Twelve communities in the basin now dispose of all or a portion of their sewage through irrigation.

3

The Water Resource

Chapter 2 outlined the major users of water in the South Saskatchewan basin and some of the geographical and climatic facts that influence how water is used. Before we can consider how water uses can be planned and before strategies can be developed, we must understand how we supply water for various uses, and how different ways of using water affect the entire system. We must understand why water quality and quantity are more critical for some uses than others, and we must realize how water management is affected by the requirements of the uses. This chapter will discuss the current supply of water, the water use or demand, and the current water quality in the South Saskatchewan system.

1. WATER SUPPLY

The water supply in the South Saskatchewan River Basin occurs as groundwater flowing in underground aquifers and as surface water flowing in rivers and streams and accumulating in lakes and reservoirs. Surface water is much more abundant than groundwater. In most areas, groundwater yields less than 25 imperial gallons per minute, the exception being the northern portion of the Red Deer basin where groundwater yields may range from 100 to 500 imperial gallons per minute. Although these low

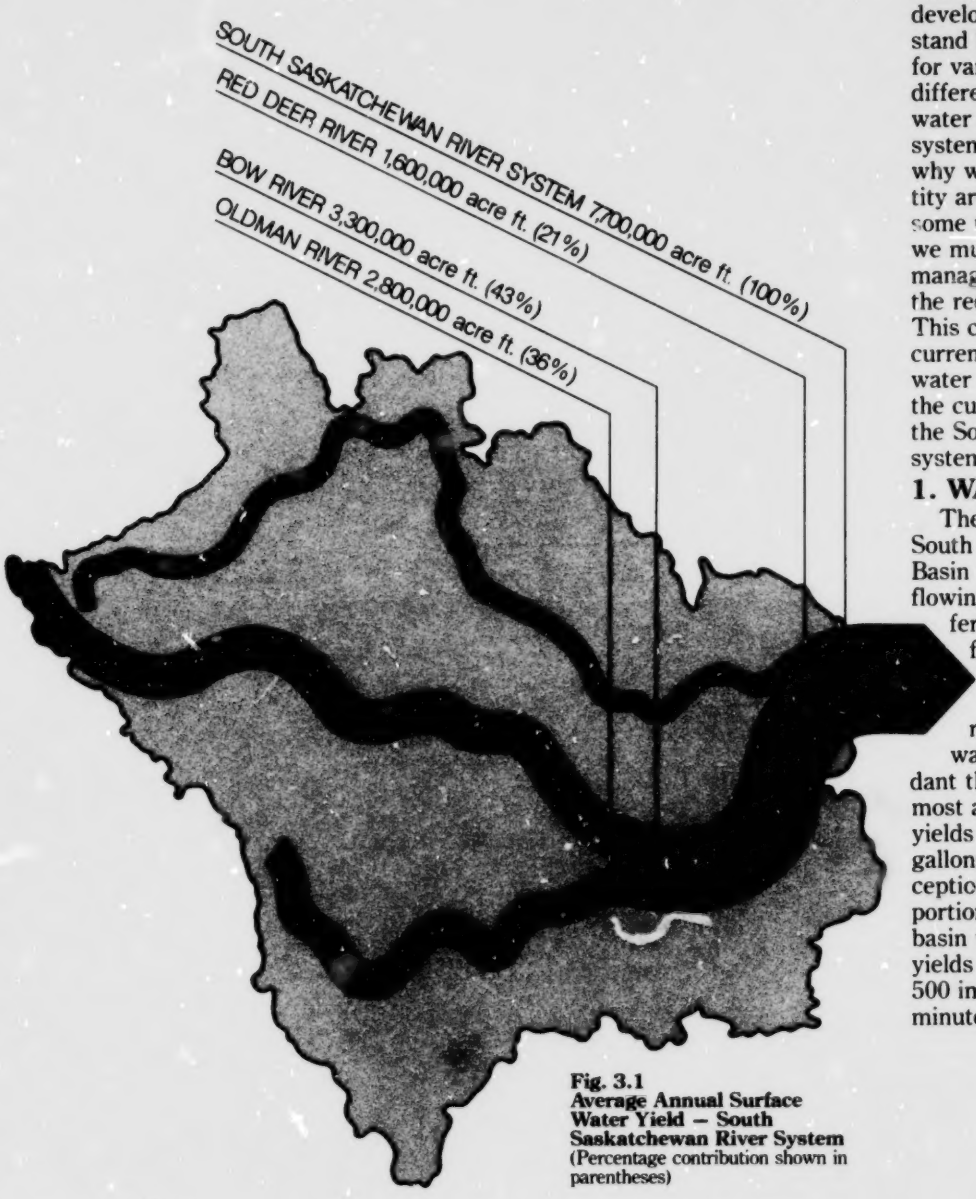

SOUTH SASKATCHEWAN RIVER SYSTEM 7,700,000 acre ft. (100%)
RED DEER RIVER 1,600,000 acre ft. (21%)
BOW RIVER 3,300,000 acre ft. (43%)
OLDMAN RIVER 2,800,000 acre ft. (36%)

Fig. 3.1
Average Annual Surface Water Yield – South Saskatchewan River System
(Percentage contribution shown in parentheses)

yields prevent groundwater from supplying major water users in the basin, it will continue to supply domestic farm and stock watering use, small industrial plants isolated from municipal supplies, and small rural communities.

The average annual surface water yield of the South Saskatchewan River system is 7.7 million acre feet, of which, on average, the Red Deer sub-basin contributes 1.6 million acre feet (21%), the Bow 3.3 million acre feet (43%) and the Oldman 2.8 million acre feet (36%). (See fig. 3.1) The South Saskatchewan River sub-basin, below the confluence of the Bow and the Oldman, is a non-contributing basin. The inflow from the few minor intermittent tributaries in this sub-basin is balanced by channel losses in the South Saskatchewan River so that it is essentially a channel for conveyance of the inflows from the Bow and Oldman.

The hydrograph in Figure 3.2 illustrates the volume of streamflow passing through the South Saskatchewan River system during each month in 1980. This hydrograph shows the typical seasonal distribution of streamflow in the major rivers in any year. The streamflows peak in the early summer following the runoff of mountain snowmelt. The streamflows are lowest in mid-winter. About 60% of the streamflow in any year passes through the system between early May and mid-July.

Since the abundance of streamflow varies significantly both seasonally and annually and from one location to another, the expected surface water supply is best understood in a historical and geographical context.

The composite hydrograph in Fig. 3.3 illustrates the periodic occurrence of successive years of above- or below-average flows, and the great range and variability in the flows in the system from year to year and over periods of several years. While the average annual flow for the 70 years on record is 7.7 million acre feet, it has been as great as 13 million acre feet in 1916 and 1951 and as little as 4 million acre feet in 1941 and 1977. Periods of three or more years of above-average flows occurred in 1915 to 1917, 1951 to 1956 and 1965 to 1968. During the most prolonged of these periods, the six years from 1951 to 1956, the annual flows in the basin averaged about 10 million acre feet. Periods of three or more years of below-average flows occurred in 1929 to 1941, 1943 to 1946, and in 1961 to 1964. The most prolonged and best-known period of low flow is that from 1929 to 1941 during the Great Depression, when the annual flow averaged about 5 million acre feet. As Table 3.1 indicates, the Red Deer, Bow and Oldman rivers have

Fig. 3.2 Natural Flow Hydrograph for the South Saskatchewan River Basin – 1980 (below confluence with Red Deer River)

Fig. 3.3 Composite Natural Flow Hydrograph – South Saskatchewan River (below confluence with Red Deer River) 1912 - 1982

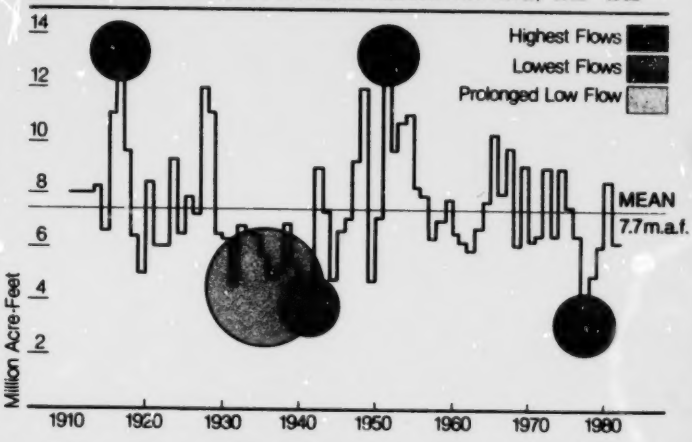


Table 3.1 Annual Variations in Natural Stream Flows. South Saskatchewan River System

Stream Flows Volume in Acre-Feet (Year of Occurence)			
River	**Mean Annual**	**Lowest Annual Mean Flow**	**Highest Annual Mean Flow**
Red Deer	1.6	.59 (1949)	4.5 (1915)
Bow	3.3	1.8 (1931)	6.2 (1916)
Oldman	2.8	1.0 (1944)	6.0 (1951)
South Saskatchewan*	7.7	3.7 (1941)	13.5 (1916)

** below confluence with Red Deer*

experienced comparable fluctuations in annual flow. While there is no coincidence of minimum annual flow in any of the three contributing rivers, there is considerable correspondence in the occurrence of below-average natural flows. This correspondence is to be expected, since most of the streamflow originates as runoff from the mountain snowmelt, and in most years, weather and precipitation patterns are comparable from one part of the headwaters region to another. The correspondence of low-flow years is most apparent during extended periods of low flow. The historic record reveals that the 24, 30 and 36 months of lowest flow on each of the Bow, Oldman and South Saskatchewan rivers occurred during the period from September 1983 to April 1942.

Irrigation District	Assessed Acres*	Number of Irrigation Farms
Bow System		
Western Irrigation District	76,029	500
Bow River Irrigation District	164,889	750
Eastern Irrigation District	229,110	1,150
Oldman System		
Lethbridge Northern Irrigation District	112,562	800
United Irrigation District	33,544	175
Mountain View, Leavitt, and Aetna Irrigation Districts	11,291	130
St. Mary River Irrigation District	293,126	1,500
Magrath Irrigation District	10,797	100
Taber Irrigation District	70,360	430
Raymond Irrigation District	33,681	274
Total Basin	1,037,173	5,809

** in 1980*

Table 3.2 Irrigation Districts-SSRB

The average annual water supply varies from area to area in the basin due to geographical differences. The mountains and foothills regions, for example, receive the most precipitation, accumulate the most snow, and have the lowest infiltration rates. The amount of runoff compared to the size of the drainage area ("unit runoff") is highest in these regions.

As the rivers flow eastward through the prairie region, where precipitation is less and little snowfall accumulates over the winter, the unit runoff is much lower and the volume of streamflow increases less dramatically. Figure 3.4 illustrates changes in unit runoff and annual streamflow from the mountains through the foothills to the prairies.

2. CURRENT WATER USE

The major water uses in the basin are irrigation, hydroelectric power generation, industry, tourism and recreation, and fisheries, and can be placed into one of two categories: consumptive uses or non-consumptive uses.

Consumptive water uses are those which withdraw water from the system but return little or none, resulting in a net decrease in the downstream flow. Irrigation and industry are consumptive uses of water, as is municipal use which includes residential, commercial and public uses such as fire-fighting and lawn-watering.

Non-consumptive water uses are those which withdraw little or no water from the system, and return most or all of what they take. Boating, water-skiing, and

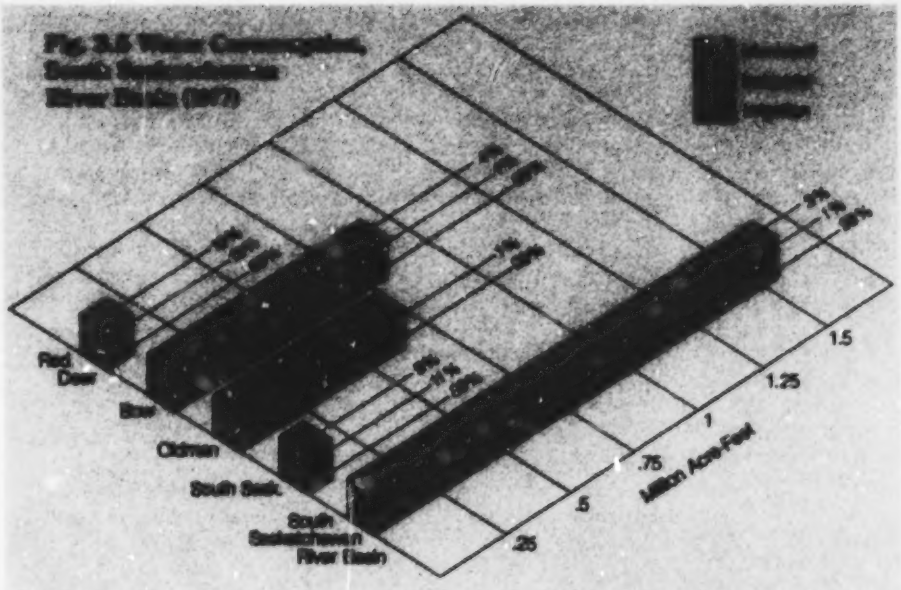
fishing are examples of non-consumptive uses which do not withdraw any water. TransAlta's Bow River hydro system, which stores water in reservoirs and then releases it for power generation, is a non-consumptive use which withdraws water but which returns virtually all of it to the system. There is no decrease in the volume of streamflow, even though the natural streamflow pattern is altered.

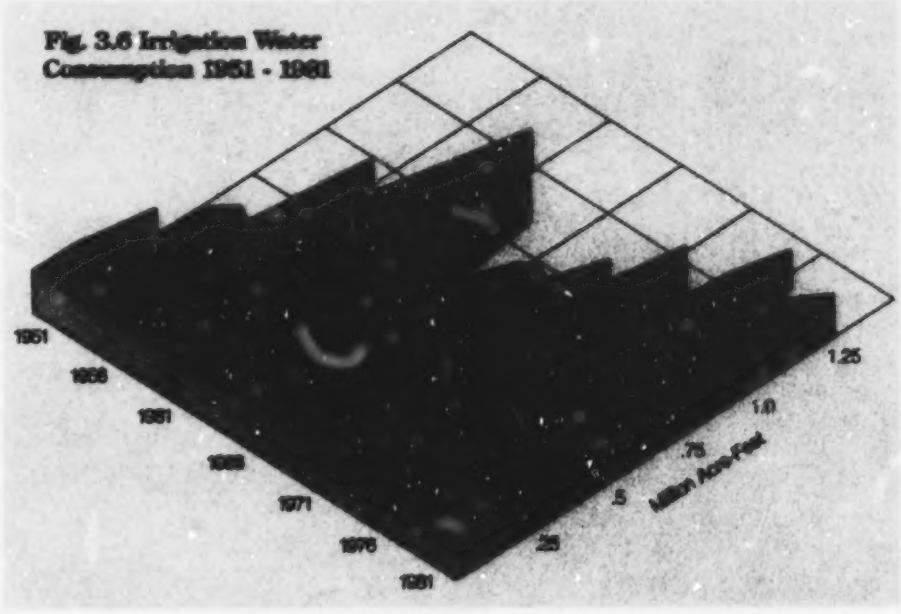
Consumptive Uses

Figure 3.5 gives a general view of the amount of water that is consumed by different uses in the basin. The year 1977 was chosen for illustration because it was a year in which flows were very low yet demands were high.

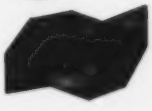
Irrigation

As Fig. 3.5 shows, irrigation is by far the greatest consumptive user of water. The variances in the annual consumption patterns for irrigation are shown in Figure 3.6, which also shows the increase in the amount of water used in irrigation over the last 30 years, reflecting the continual growth in irrigation development in the basin. Table 3.2 shows the number of farms and the assessed acreage in irrigation districts in the basin in 1980.





Average Annual Unit Run-Off (Acre-Ft./Sq.-Mi.)


Mean Annual Water Yield (Million Acre-Ft.)

◁ **Fig. 3.4**
Natural Flow Characteristics South Saskatchewan River System

Municipal Use

The four major urban centres obtain their water supplies from the rivers on which they are situated: Red Deer from the Red Deer River, Calgary from the Bow and Elbow rivers, Lethbridge from the Oldman River, and Medicine Hat from the South Saskatchewan River. Of these, only Calgary owns and operates an onstream storage reservoir for municipal purposes, the Glenmore Reservoir on the Elbow River. Calgary's municipal withdrawals from the Bow are obtained from TransAlta Utilities' Bearspaw Reservoir. The other three urban centres draw their water directly from the major rivers. The municipal uses of these centres account for over 90% of the total municipal withdrawals from surface water in the basin. An additional 67 smaller centres, with a combined population of about 110,000, obtain their municipal water supplies from surface water. Of these, six are served by the Mountain View Water Line from the Red Deer River, 32 obtain water from the Bow or Oldman system through the works of irrigation districts, and 29 draw water directly from a variety of surface sources. Figure 3.7 indicates the amount of surface water consumed by municipal users in a recent year. The remaining rural communities in the basin, about 100 in all, rely on groundwater to supply their needs.

Industrial Use

Industries in the South Saskatchewan River Basin do not use much water. In 1981, there were 141 industries in the basin that used more than one-third of an acre foot of water each per year. Ninety-seven of these were in the four major urban centres. These industries together withdrew 139,000 acre feet of water in 1981 (85% from private surface sources and 8% from municipal water supply systems) and discharged 116,000 acre feet, consuming about 23,000 acre feet. An additional 7,000 acre feet was consumed by the oil industry for well injection in secondary crude oil recovery operations, bringing total industrial water consumption in the basin in 1981 to 30,000 acre feet. (See Figure 3.8.)

Non-Consumptive Uses

Hydroelectric Power Generation, Recreation and Fish Habitat

As mentioned in Chapter 2, TransAlta Utilities owns and operates 11 hydro generating plants on the Bow River. Recreationists use the reservoirs which are part of TransAlta's system, as well as Glenmore Reservoir in Calgary, the larger reservoirs in the irrigation headworks system such as St. Mary's and Lake McGregor, and Lake Newell in the Eastern Irrigation District. However, recreational use is not the first priority in the operation of any of these reservoirs.

River recreation and fish habitat are two other non-consumptive uses which are commonly referred to as "instream" uses.

Other Water Uses

There are two other uses that have a significant influence on the use and management of the river system in Alberta. The first of these is the downstream use of water in the Province of Saskatchewan. The quantity of water that must be provided to Saskatchewan is dictated by the terms of the Master Agreement on Apportionment, which stipulates that 50% of the volume of natural streamflow from the rivers in the South Saskatchewan basin must pass downstream to Saskatchewan each year. The second use is waste disposal, which does not consume any quantity of water. However, since this use consumes part of the assimilative capacity of the river system and may reduce the quality of the receiving water to a point that it cannot be used for other purposes, waste disposal might be considered a consumptive use from a water quality perspective.

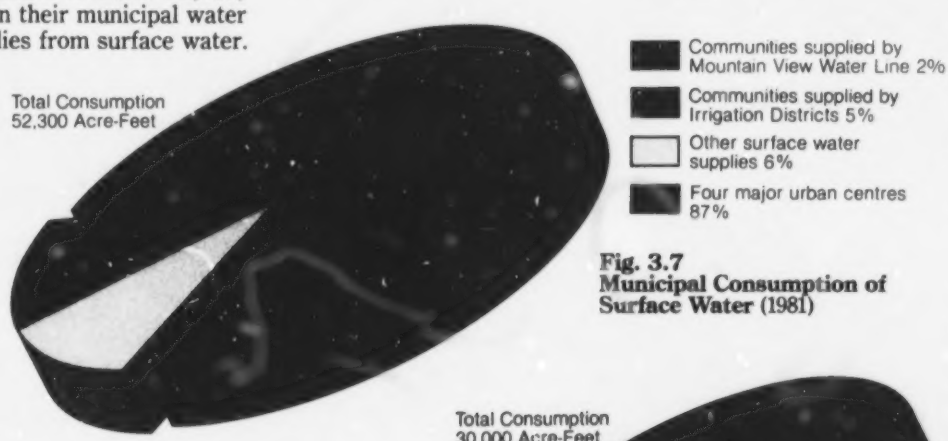

Total Consumption
52,300 Acre-Feet
Communities supplied by Mountain View Water Line 2%
Communities supplied by Irrigation Districts 5%
Other surface water supplies 6%
Four major urban centres 87%

Fig. 3.7
Municipal Consumption of Surface Water (1981)

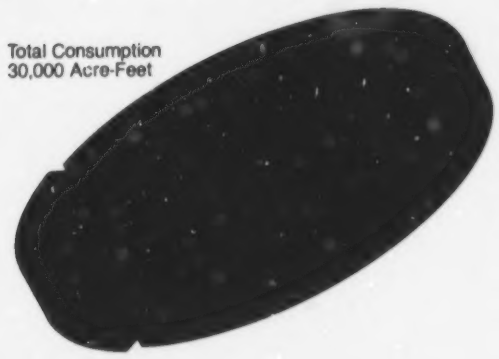


Fig. 3.8
Industrial Consumption of Surface Water (1981)

The characteristics of these uses, the management measures peculiar to each, and the benefits and conflicts inherent in joint use of the river system are discussed more fully in Chapter 4.

3. WATER QUALITY

While the quality of the water in the Red Deer, Bow and Oldman rivers is generally very good upstream from the major urban centres, all of the four sub-basins face similar water quality problems but experience them to different degrees. The kinds of uses of water make a great difference: one basin may have larger urban centres than another, for example. To understand the whole water quality picture in the entire South Saskatchewan basin, each sub-basin must be examined.

Red Deer Sub-Basin

In the Red Deer basin downstream from the city of Red Deer the quality remains generally good, although during the winter months dissolved oxygen levels in the lower reaches have been extremely low in some years. The process of oxygen depletion in the river begins upstream from the city of Red Deer, where a number of the major tributaries that drain muskeg areas in their headwaters carry dissolved organic materials into the river. These are supplemented downstream by additional loadings from the Red Deer sewage treatment plant. The decomposition of this organic material, which uses up oxygen from the river, continues well downstream of the city. In the winter, when the river is covered with ice, dissolved oxygen in the water is not replenished by natural aeration. The dissolved oxygen in the river downstream from Drumheller has, at times, been totally depleted. The operation of Dickson Dam will augment winter flows in the Red Deer River and is expected to rectify this situation. Sediment loads are frequently extreme in the lower reaches due to the rapid rates of runoff and erosion in the badlands area.

Upsteam water quality is generally very good in the South Saskatchewan River Basin.

Bow Sub-Basin

The principal water quality problems in the Bow River downstream from Calgary are caused by the prolific growth of algae and aquatic weeds and intermittent high levels of coliform bacteria. The detrimental effects of excessive weed and algae growth include the fouling of municipal and industrial water intakes, irrigation works and equipment, and fish ladders; the impairment of fish productivity and recreational activity; and the unpleasant taste and odor that the decaying weeds and algae can impart to public water supplies. The weeds and algae also detract from the general appearance of the rivers. The high coliform levels that sometimes occur as far downstream as the Carseland weir make the river unsuitable for water contact activities such as swimming, and more intensive application of conventional water treatment technologies may be required to make municipal water supplies suitable for drinking. These would include increased chlorination; flocculation, where a chemical agent draws together suspended particles; or sedimentation, the gravitational settling of suspended material.

There is no significant effect on water quality due to salt concentrations in the river, which increase marginally from upstream to downstream, or to sediment loads which are higher in the lower reaches of the rivers.

Phenolic compounds, which give fish an unpleasant taste, have been a problem in the Bow in the past. However, the occurrence of phenolics has been reduced considerably over the last decade.

Iron and manganese concentrations increase from upstream to downstream. The sources of these metals, neither of which is harmful to health at the monitored levels, are primarily natural erosion and groundwater inflows. Aluminum concentrations increase appreciably downstream from Calgary, most likely due to the use of alum for phosphorus removal in Calgary's sewage treatment plants. Lead, copper, cadmium, chromium, nickel and zinc are rarely detected in water samples from the Bow, and never at high concentrations. Mercury has been detected in fish and

aquatic plants in the rivers in the South Saskatchewan basin, and the provincial government has suggested limits on human consumption of certain fish species. The mercury is thought to originate from natural sources, since there are no known municipal or industrial sources of mercury in the basin.

Herbicide and pesticide levels in the Bow remain near the limits of analytical detection for most parameters monitored. Only alpha BHC and 2,4-D have been detected consistently. The amount of 2,4-D in the water, although still at a very low level, is increasing.

Nitrogen and phosphorous compounds in the river waters increase markedly downstream from the city of Calgary's sewage treatment plants. Phosphorous concentrations have been reduced substantially since advanced phosphorous removal was implemented at Calgary's two sewage treatment plants in early 1983. It is expected that this treatment will reduce the growth of algae and weeds in the Bow River.

In 1981 there were 18 municipal and industrial discharges into the Bow or tributaries to the Bow in the Calgary area that contribute to these conditions. The industrial discharges include Canada Cement Lafarge at Exshaw, the Shell Canada gas plant at Jumping Pound, a Cominco fertilizer plant at Carseland, a second in Calgary, and the Western Co-operative fertilizer plant, the Gulf Canada refinery and Burnco gravel washing operation, all located in Calgary. The municipal sewage treatment plants include those at Longview and High River on the Highwood River; Turner Valley, Black Diamond and Okotoks on the Sheep River; and Canmore, Cochrane and Calgary's Bonnybrook and Fish Creek plants on the Bow River.

As indicated in Figure 3.9, treated sewage and urban runoff from the city of Calgary is about five times that of the other discharges combined. Figure 3.10 indicates that effluents from sewage treatment plants account for most of the loadings of major constituents. The exceptions are lead and suspended solids which come primarily from urban runoff. It is estimated that the phosphorous loadings from sewage treatment plants indicated in Figure 3.10 have been reduced by about 75% since the introduction of advanced phosphorous removal at Calgary's sewage treatment plants in early 1983.

Oldman Sub-Basin

The quality of the Oldman River is considered good at Fort MacLeod; poorer quality in the headwater reaches is localized. There is no municipal development on the Upper Oldman, Livingstone, or Castle drainage basins. The quality of the Crowsnest River, however, is influenced by both municipal and industrial discharges. Coal mining operations have contributed suspended solids and iron to the Crowsnest River in the past; in recent years, mine closures and improved regulation have reduced this discharge. Municipalities in the Crowsnest area also discharge treated sewage to the river, but only the Crowsnest River is affected. The town of Pincher Creek, which discharges treated sewage to Pincher Creek, is the only other wastewater discharge to the Oldman system upstream of Fort MacLeod. The most important factor affecting quality between Fort MacLeod and Lethbridge is sediment input from tributaries and bank erosion. During high flow periods, the Belly and St. Mary rivers carry high suspended solid loads which in turn influence particulate-related water quality parameters such as soil bacteria, certain nutrients and metals.

Downstream from Lethbridge, Oldman River water quality is affected by municipal and industrial discharges and irrigation return flow. Treated sewage effluent from Lethbridge alters water quality and biological conditions in the Oldman in much the same way that Calgary's sewage alters the Bow. Elevated nutrient levels cause aquatic algae to bloom during late summer and fall. For a short distance downstream from Lethbridge, bacteriological levels exceed standards that would permit recreational water use. The sugar beet processing plant at Taber is the only major industrial source of discharge to the Oldman River. It discharges during fall and winter only. Irrigation return flows to the Oldman currently have a minimal impact on salinity in the river.

South Saskatchewan Sub-Basin

The water quality of the South Saskatchewan River depends primarily on the quality of the Bow and Oldman rivers since both contribute to its flows. The highest concentrations of contaminants associated with upstream discharges occur in the river during late fall and winter, when the capacities of the Bow and Oldman rivers to assimilate the waste discharged to them are minimal. Industrial and municipal discharges occur only in the Medicine Hat area, and include the effluent from one fertilizer manufacturing plant and the Medicine Hat sanitary sewage treatment plant. These discharges do not have a long-lasting effect on the South Saskatchewan River quality.

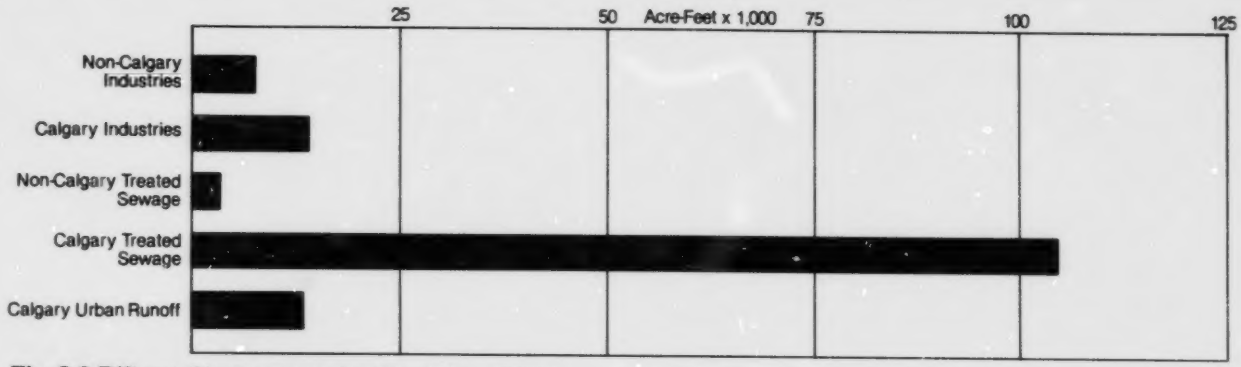


Fig. 3.9 Effluent Discharges to the Bow River (1980)

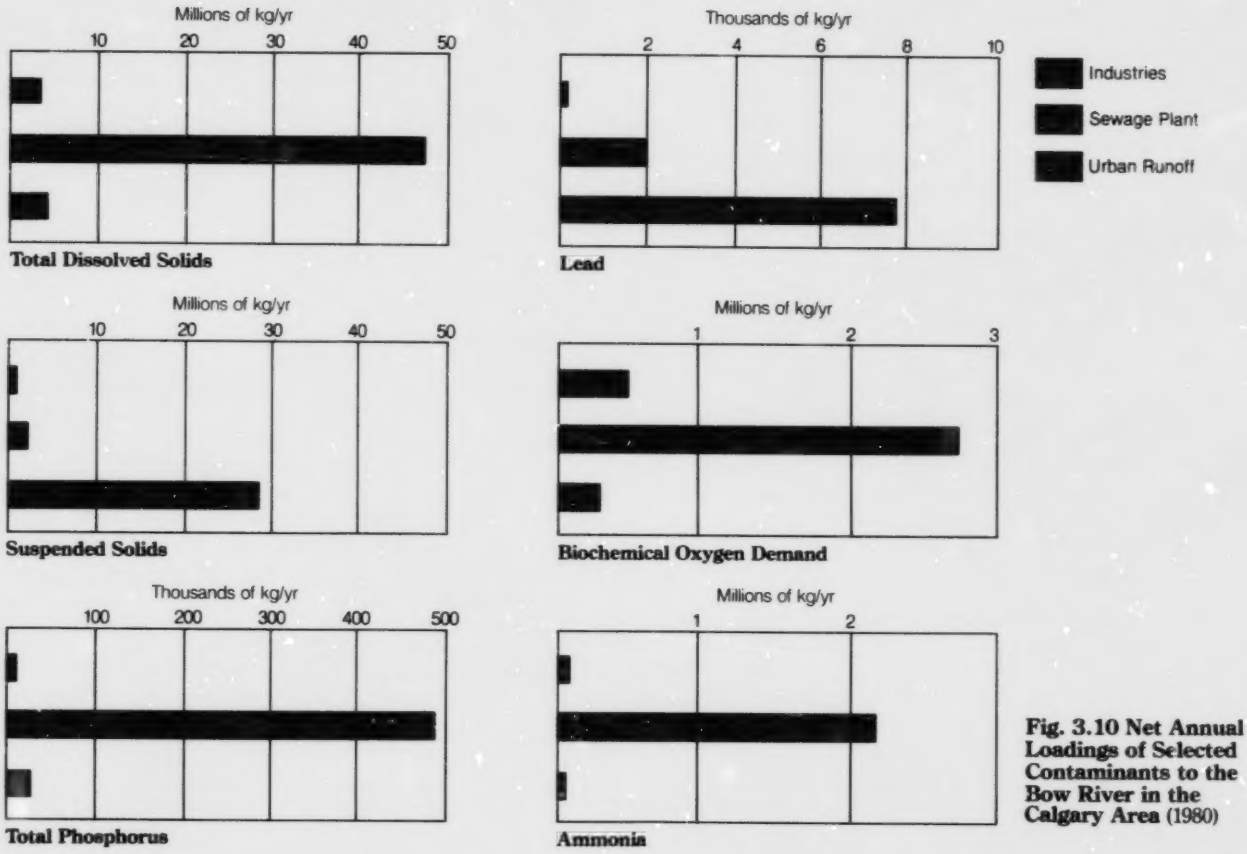


Fig. 3.10 Net Annual Loadings of Selected Contaminants to the Bow River in the Calgary Area (1980)

4

Water Use & Management Considerations

As discussed in Chapter 2, there are seven major categories of water use in the basin: irrigation, hydroelectric generation, municipal, industrial, fish habitat, recreation and waste disposal. Each of these water uses requires water of a particular quality and quantity in a particular location and available at certain times. Each is unique in the way that water must be managed to satisfy its requirements. While these unique demands do not rule out the joint use of the river system by the different users, joint use does involve some fundamental conflicts which cannot always be resolved to the absolute satisfaction of everyone.

Figure 4.1 is a schematic representation of the variety of water uses that occur in the South Saskatchewan River Basin. (See pp. 26-27.)

In this chapter we will examine some of the more significant water use and management practices in the basin and the relationships between them, and identify some of the conflicts that result. As well, some of the legislation that currently guides water use and management practices will be reviewed.

1. IRRIGATION

More water is used for irrigation, and more money, manpower and infrastructure is required to manage water for irrigation than for any other water use in the South Saskatchewan River Basin. About 90% of the land that is irrigated in the basin is supplied with water through the works of irrigation districts.

Irrigation involves three basic operations: diverting water from a source such as a river, conveying it to the farm, and applying it to the land. (See Fig. 4.1)

A typical irrigation development in the basin uses water diverted from a river through "headworks" (basically a diversion structure and a canal) which are owned and operated by Alberta Environment or by the irrigation district, as is the case with the Eastern Irrigation District (EID) and the United Irrigation District (UID). Discussions are underway for the eventual transfer of these headworks to Alberta Environment, in accordance with provincial government policy established in 1975. Figure 4.2 provides more information about the water supply systems serving the irrigation districts.

The headworks system carries the water to the irrigation district's boundaries. The district delivers the water through canals and water control works to headgates at each farm.

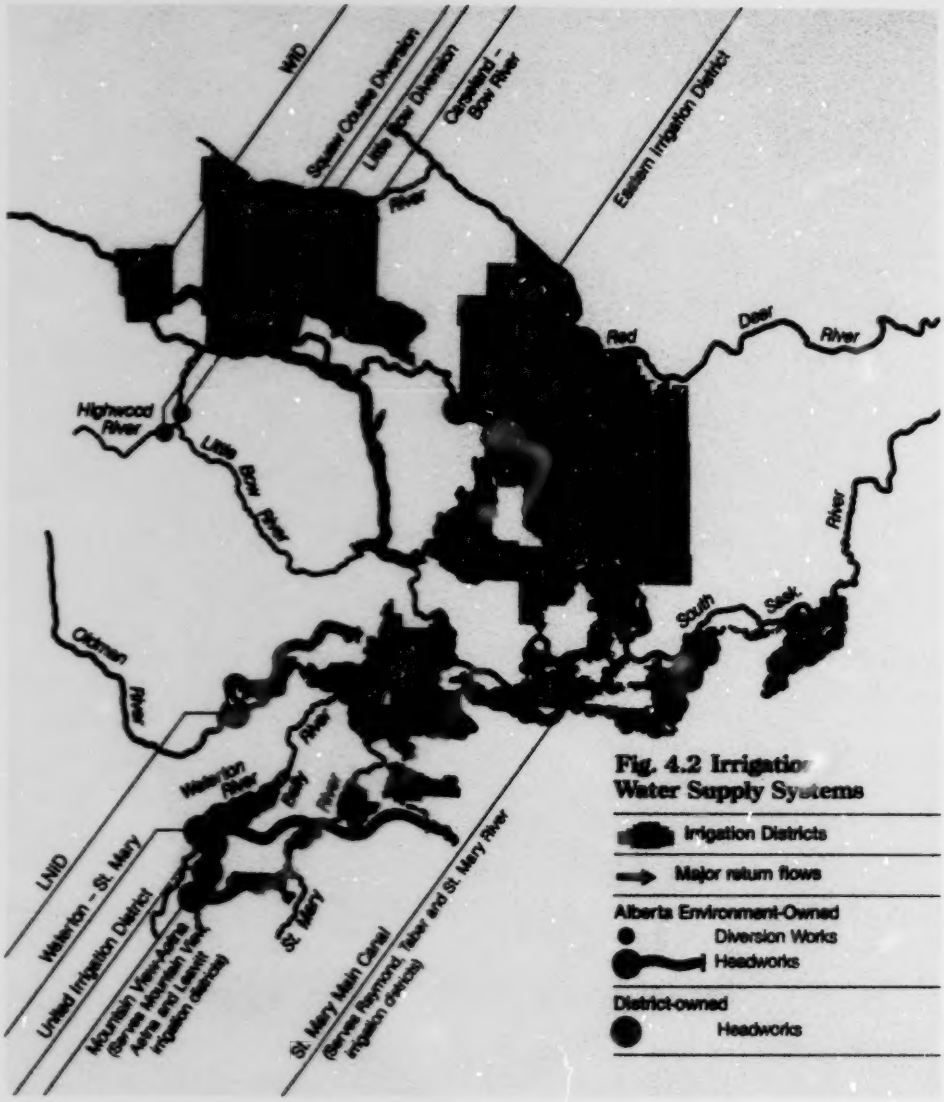


Fig. 4.2 Irrigation Water Supply Systems

Fig. 1.1

A Schematic of Water Uses on a River System

Industry
Outfall
Outfall
Reservoir

A Ditchrider at work

The farmers apply the water to their fields using one of several methods of water application ranging from the labour-intensive flood or gravity flow system to fully-automated sprinkler systems.

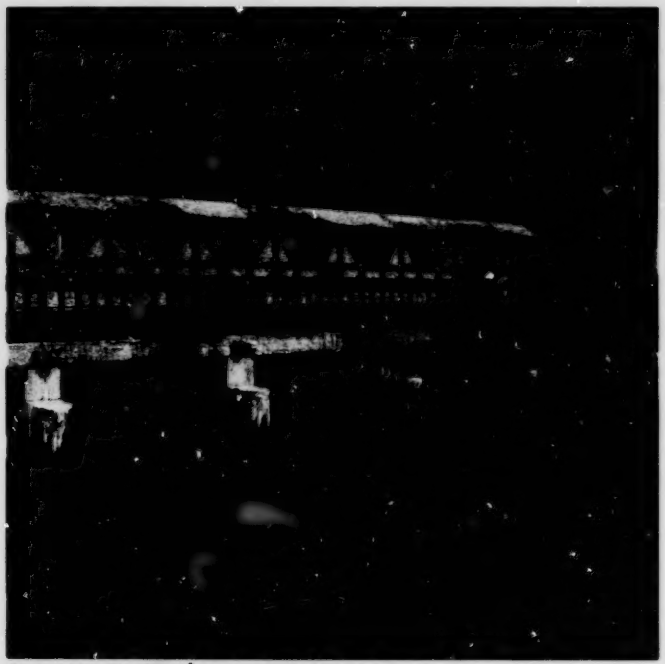
The water delivery system operates on the basis of the farmer's demands. Farmers decide which fields they want to irrigate, and when they want to irrigate them, and place an order for water with the ditchrider, the district employee responsible for managing a unit of the irrigation district's water distribution system. Ditchriders estimate how much water the farmers in their units will need, and when they will need it, and place orders for water with the water master, a district employee responsible for managing a larger unit such as a main canal system, who places an order for the delivery of water with the headworks system. The headworks system staff divert the required amount of water from the river or release it from headworks storage at the correct rate of flow to meet the requirements of the irrigation district. Any water delivered in excess of requirements is spilled, either from the district's canal system or on the farm. Some of this water, which is referred to as "operational spill" or "farm spill", returns to the river system through the district drainage system and is called "return flow".

Patterns of Irrigation Water Use

The seasonal relationships between the natural flow in a river, irrigation water demand and the operation of an irrigation water storage reservoir are illustrated in Figure 4.3. Irrigation diversions begin in April to prime canals and begin replenishing storage reservoirs, which are replenished as early in the year as possible when river flows are high, and drawn down in the late summer and early autumn when river flows are declining. Diversions continue through the summer with the application of water to crops reaching a peak in July and August. Some farmers continue irrigating their land in the fall to provide carryover soil moisture for the following spring.

Irrigation Efficiency

There are different ways of looking at how much water is used in irrigation. In the simplest sense, and applying the broadest definition of use, the amount of water used is the amount that is diverted from rivers for that purpose. This is commonly referred to as the gross diversion for irrigation,



Eastern Irrigation District Headworks at Bassano Dam

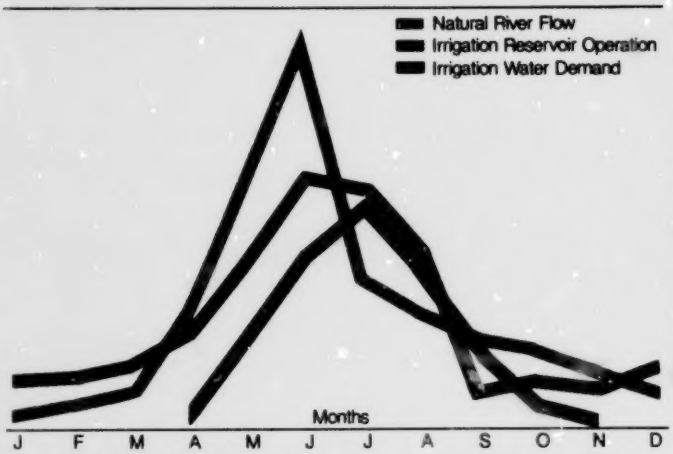


Fig. 4.3 Seasonal Relationships – Natural Flow, Irrigation Water Demand and Irrigation Storage Reservoir Operation

A centre pivot irrigation system

which is equal to the water consumed in the irrigation operation plus the return flow to the river.

The amount of water consumed in an irrigation operation includes what is lost through evaporation and seepage from storage reservoirs and conveyance canals, operational and farm losses, and the water applied to fields. (See Fig. 4.4) The amount of return flow from an irrigation district depends on how the distribution system and the farmer's application systems are designed and operated.

For some districts in the basin, the return flow appears to be a fairly constant percentage of the gross diversion. For others, the percentage is much less in dry years when the demand for irrigation water is greater, suggesting that in these districts, water is used and managed more carefully in critical years.

The fact that more water must be diverted for irrigation than is needed to satisfy the crop water requirement has given rise to the concept of irrigation water use efficiency. Irrigation water use efficiency can be defined for each independent component of an irrigation system; for example, headworks efficiency, conveyance canal efficiency, or on-farm efficiency. The most common definition, usually referred to as "district efficiency", is expressed as the ratio of the amount of water a crop needs to the amount of water delivered to an irrigation district. This definition includes both conveyance canal efficiency and on-farm efficiency; it disregards the efficiency of the headworks component of a system. Thus, in a perfectly designed and operated system, with a minimum of opportunity for evaporation or seepage, the amount of water delivered to a district to satisfy the crop water requirements would, in theory, approach 100%. In reality, however, because water losses do occur, irrigation water use efficiencies are considerably less than 100%. Although existing data are inadequate to accurately assess irrigation water use efficiencies in the basin, gross estimates based on the available data suggest that district efficiencies range from 30% to 60%.

Most estimates of irrigation efficiencies are based on the assumption that all irrigators apply enough water to their land to maintain the soil moisture required to obtain the maximum yield from their crops. A more realistic assumption would be that irrigators apply enough water to produce crop yields that maximize their economic return – a yield that may be less than the maximum possible, and thus, one that requires less water.

In theory, farmers base their water demands on which of these objectives they wish to achieve: maximum yield or maximum economic return. In practice the situation is somewhat different. On the average, farmers in the basin appear to apply between 20% and 70% of the amounts of water estimated to be required to maximize the economic return from the crops irrigated. No studies have been done that explain why this is the case, however, there are a number of factors that could account for it:

- farmers lack completely accurate information about the moisture requirements of their crops;
- not all farmers depend solely or even mainly on the maximum returns from irrigated crops to keep their farm operations economically viable;
- not all crops in the prevailing mix of crops require irrigation to provide some economic return;
- the methods of irrigation used by farmers;
- the capacity of the farmers' irrigation equipment;
- the amount of labour required for irrigation and the cost and availability of reliable (experienced) labour;
- the coincidence of the irrigation schedule with the schedule of other agricultural operations on the farm.

To the extent that actual irrigation water applications are less than the theoretical crop water requirements, irrigation water use efficiencies will be even less than those estimated using available data. At the same time, the crop yields from this practice are less than maximum and even less than required for maximum economic return from the irrigated crop.

The management and use of water for irrigation may conflict with other uses.

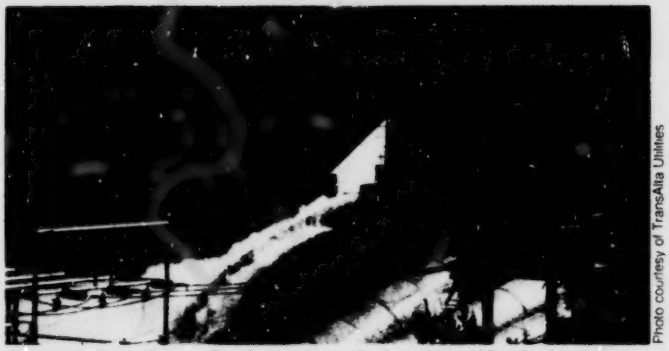


Photo courtesy of TransAlta Utilities

Kananaskis Power Plant – The Kananaskis facility located east of Lac des Arcs is an example of a "run-of-river" or base-load plant.

Withdrawal of water from a river, or impoundment of water in an onstream storage reservoir for irrigation can create low streamflow conditions that are unsuitable for fish habitat, that reduce the capacity of a river to dilute and assimilate wastes, and that foster prolific growths of aquatic weeds and algae. The combination of these conditions is unsuitable aesthetically and for recreation. In southern Alberta where there are few natural lakes, many irrigation reservoirs are used for recreation. If the water levels in these reservoirs drop as a result of water being released for irrigation, the reservoirs become less attractive for recreation. The conditions that characterize these conflicts are most apparent during the warmer summer months when natural streamflows are declining, and when irrigation water demands and recreational activities are at their peak.

2. HYDROELECTRIC GENERATION

The use of water in hydroelectric generation involves impounding streamflow and later releasing it through turbines to generate electrical energy. Streamflow is impounded for two purposes: to create head (the vertical distance that the water falls) to drive the turbines that generate electricity, and to store water during high flow periods so that it can be released to generate electricity during low flow periods. Figure 4.1 illustrates a hydro generating system similar to that of TransAlta Utilities on the Bow River system.

From an operational perspective, there are two types of plants in TransAlta's Bow River hydro system; peaking plants, which operate on water released from storage, and base-load (run-of-river) plants which operate on natural river flows. The natural river flows are augmented by water released from upstream storage when peaking plants are in operation. The peaking plants, with the storage reservoirs from which they operate in parentheses, are: Cascade (Minnewanka), Three Sisters, Spray, Rundle (Spray). Interlakes (Upper Kananaskis) and Pocaterra

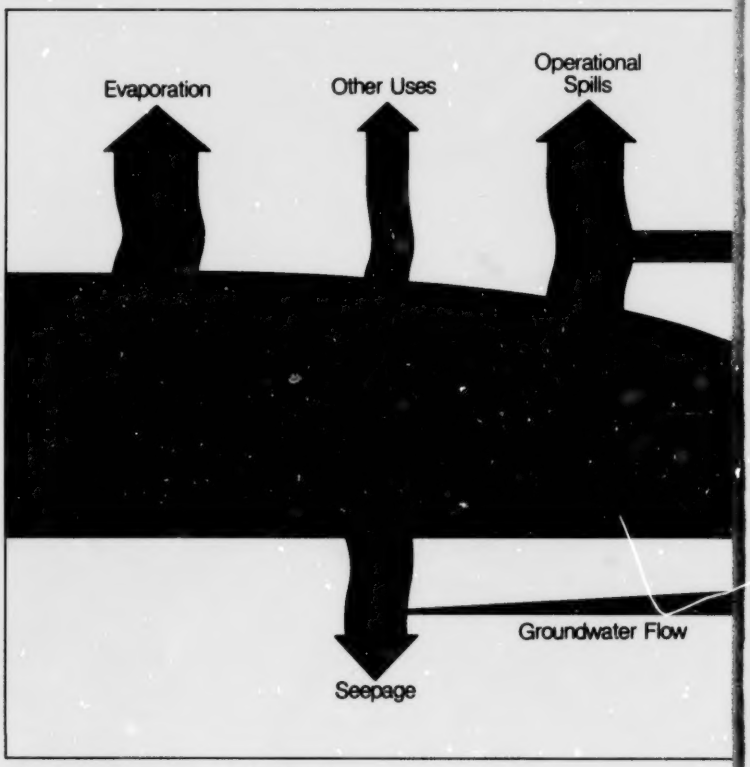


Fig. 4.4 Water Use in Irrigation

(Lower Kananaskis). The base-load (run-of-river) plants are Kananaskis, Horseshoe, Ghost and Bearspaw on the Bow River and Barrier on the Kananaskis River.

As indicated in Figure 4.5 TransAlta's Bow River hydro system generates electricity fairly uniformly throughout the year.

Generally each storage reservoir in the system is operated to achieve a planned month-end elevation. The planned outflow for each plant, and thus the generation from the associated plants, is based on a forecast of inflow to the reservoir during the month. The reservoirs are filled during the period from May to September – most rapidly during June and July when streamflow from mountain snowmelt runoff is at its peak – with the objective of filling all reservoirs to their full supply level by October. Reservoir draw-down begins in late October when natural streamflow and inflow to reservoirs has diminished and demands for electricity are increasing. The reservoirs are drawn down over the winter months, reaching their lowest levels in late April or early May. A preferred annual operating pattern for the hydro storage reservoirs in the Bow system is illustrated in Figure 4.6. As indicated, even in a high run-off year the reservoir system is not drawn down to minimum operating level over the winter so that there remains a reserve of water for generating electricity in an emergency.

Although each plant operates somewhat differently, the general pattern of daily energy production from the co-ordinated operation of these plants is as depicted in Figure 4.7. The combined water outflow from storage reservoirs above these plants follows a similar pattern, although on any given day the outflow from one reservoir or another could differ markedly. The run-of-river plants operate somewhat similarly, but on a different schedule and with a significant moderation of peak flows. Barrier is operated to even out the flows from the Kananaskis River where it enters the Bow above the Kananaskis and Horseshoe plants. Ghost is operated essentially as a peaking plant in winter, and as a base load plant in summer, with minor peaking use. The operation of Ghost is somewhat limited by the capacity of the Bearspaw reservoir downstream.

Fig. 4.5 Typical Monthly Generation of Electricity (as a percent of annual generation), **Bow River Hydro System**

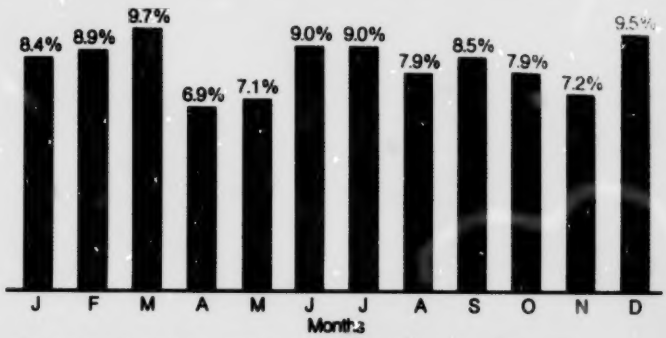
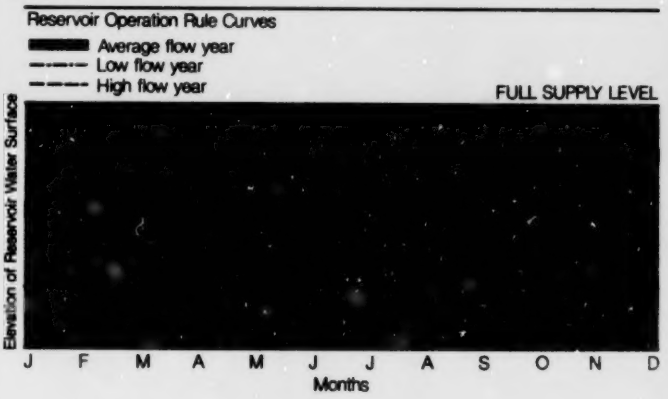
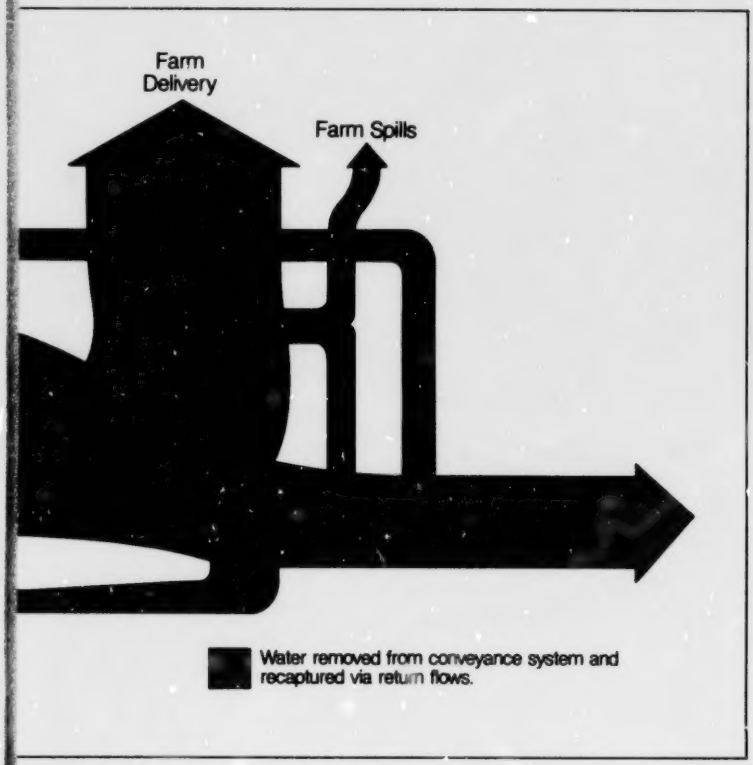


Fig. 4.6 Preferred Annual Operating Pattern, Bow River Hydo System Reservoirs


Reservoir Operation Rule Curves
Average flow year
Low flow year
High flow year
FULL SUPPLY LEVEL
Elevation of Reservoir Water Surface
J F M A M J J A S O N D
Months



Bearspaw is operated to minimize fluctuations in the flow of the Bow River through Calgary.

Figure 4.8 illustrates the effect of TransAlta's hydro operations on the annual flow pattern of the Bow River. When the hydrograph in this illustration is compared to the typical hydro reservoir operation curve in Figure 4.6, it can be seen that during the period from May to September, when storage in reservoirs is being replenished, the average monthly flow in the Bow is reduced by up to 2500 cfs. During the winter months, when water is being released from storage to generate electricity, the average monthly flow in the Bow is increased by as much as 1000 cfs.

The conflicts that arise between the use of water for hydro generation and for other uses generally result from the storage and release patterns of hydro reservoirs. By examining Figure 4.9, it can be seen that the annual pattern of hydro reservoir operation conflicts with the annual pattern of irrigation water use. Between mid-July and September, when natural streamflow is receding, hydro reservoirs are replenishing storage, yet at the same time, irrigation demands are the greatest and irrigation storage reservoirs are being drawn down.

When streamflow is high, the action of the water scours the river bottom, improving water quality by removing nutrient-rich sediments and the roots of aquatic weeds. This process is reduced when peak streamflows decrease.

The daily or hourly operating patterns of peaking plants result in fluctuations in the amount of streamflow in downstream channels, which create poor habitat conditions for fish, and in the winter, result in ice build-ups in the river channel. This is of particular concern in Calgary, where ice jamming threatens bridges and causes flooding in the low-lying areas. Since Bearspaw reservoir began operating in 1954, ice problems in the Bow in Calgary have diminished considerably, and the more uniform seasonal flows are more suitable for recreational and irrigation use.

The increased winter streamflow that results from the release of water from hydro reservoirs is beneficial for fish habitat and water quality, and contributes to the maintenance of Alberta's commitments to apportionment. Winter flows prevent the river from becoming completely covered over with ice, and help maintain dissolved oxygen in the river water for the fish.

Fig. 4.7 General Pattern of Daily Energy Production, Bow River Hydro System

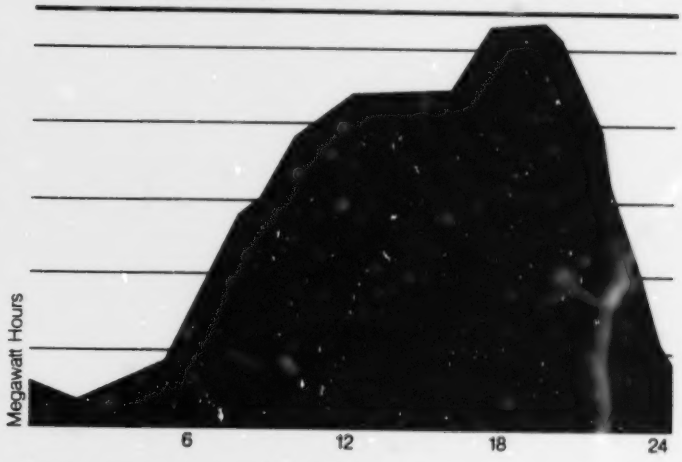


Fig. 4.8 Average Natural and Regulated Flow, Bow River at Calgary

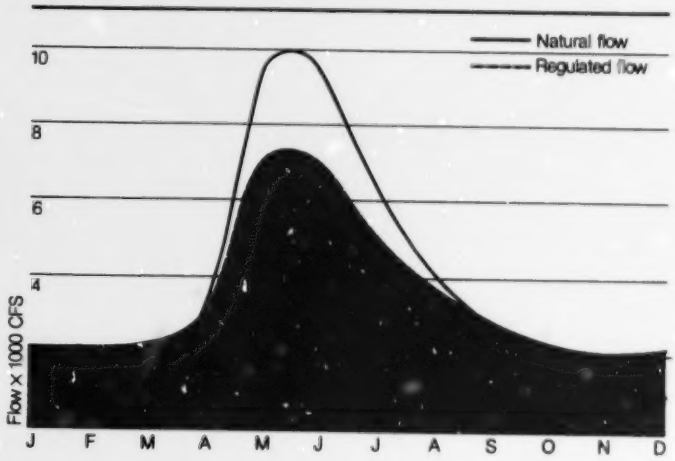
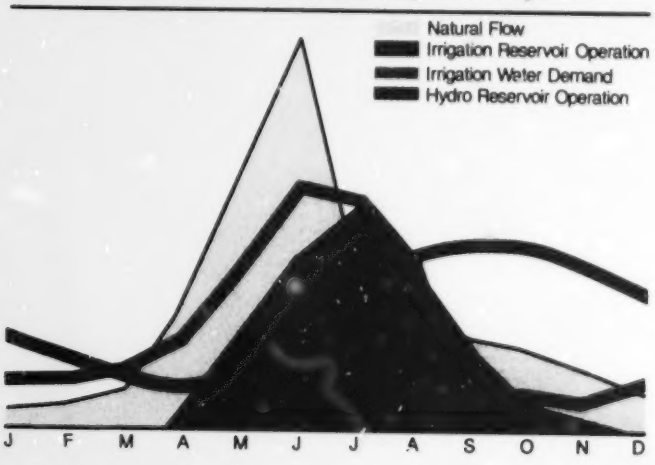


Fig. 4.9 Reservoir Operating Patterns: Irrigation vs. Hydro



3. FISH HABITAT

Freshwater fish populations adapt to a range of conditions which change seasonally and annually. The volume of water, the speed of the streamflow, and the temperature of the water all influence the suitability of a body of water to support fish.

No one flow level can be established which is best during all seasons and for all life stages of various fish species. Fish fry, for example, are tolerant of a narrower range of habitat conditions than juveniles or adults. Obviously if flows drop too low, fish habitat is reduced simply because there is less area covered by water. Decreased living space, decreased spawning habitat, and increased competition for reduced food supplies and shelter areas create stress which make fish more susceptible to disease and predators. Reduced flows in smaller streams, where levels normally fluctuate more widely, may actually trap fry in the rearing areas in backwaters before they can move to deeper water.

When flows increase beyond a certain level, however, fish habitat again decreases. The speed of the streamflow becomes too high, and erosion becomes a problem. However, periodic high flows are necessary to maintain the characteristics of a river channel. High flows also flush out sediments that fill spaces in the gravel in spawning beds, suffocating eggs and covering food supplies. Spring flushing flows stimulate some species to begin upstream spawning migrations.

The best conditions for fish lie between the two extremes of high and low flows. In all life stages from fry to adult, fish require suitable temperature conditions, oxygen, food, shelter, and spawning habitat. Since all these requirements may not be met in a confined area, many fish species migrate over great distances to find suitable conditions.

Pools of deep, slow-moving water and riffles (fast-flowing, shallow, broken water) in a stream are required to provide adequate fish habitat. (See Fig. 4.10) Pools provide shelter and resting areas. In winter, deep pools may be the only ice-free areas where fish can congregate and survive until spring. In summer, pools can provide cooler water when temperatures in shallow

water approach upper tolerance limits. Riffles are the primary food-producing areas, they keep up the supply of oxygen in the water, and provide spawning grounds. Since the velocity of the water is higher in riffles, riverbed materials are coarser than in pools. The combination of the clean gravel and high oxygen levels in riffles makes suitable spawning habitat for numerous species such as trout and mountain whitefish. Adequate flow over spawning riffles is essential during the incubation period, in order to prevent destruction of the eggs and to maintain the oxygen level. Under low flow conditions, riffles may impede the movement of fish. Natural streamflow conditions do not necessarily provide the best fish habitat conditions because of seasonal variations in flow and limited food producing capability. Human activity has its effects as well. Conflicts arise between the use of a river for hydroelectric generation, irrigation, or municipal/industrial water supply and waste disposal, and the use of a river as a habitat for fish.

Maintaining fish habitat may restrict the operations of hydro plants or require more extensive and expensive waste water treatment or disposal alternatives. Fish habitat may be maintained at the expense of irrigators who may not be able to withdraw sufficient water to apply to their crops, or who may have to reduce the amount of land they irrigate. Conversely, if any of these uses are given priority for use of the water, the resulting impact on fish could be severe.

Managing water in the South Saskatchewan basin requires an understanding of these kinds of trade-offs.

4. RECREATION

In the South Saskatchewan basin, demands for water recreation uses are concentrated near urban centres, in areas of outstanding scenery, and at irrigation reservoirs. The water requirements for each type of activity vary.

Recreational activities that involve direct contact with the water such as swimming, waterskiing, and windsurfing are very sensitive to water quality problems, particularly the presence of pathogenic bacteria and viruses, algae or weeds. The requirements for fishing can be equally sensitive if water quality threatens fish habitat. Water quality requirements for other recreational activities are not as stringent as for water contact recreation, although the presence of pathogens is a hazard in cases of accidental dunking, and extreme weed and algae growth can have a major impact on the aesthetic quality. Power boating and canoeing require, at a minimum, river or reservoir water levels that are adequate for safe, unimpeded navigation. Fishing from a bank or shore only requires water levels that ensure productive fish habitat, while activities like camping, hiking, and sightseeing require flows that are aesthetically pleasing. Although each can tolerate a fair degree of water level fluctuation, the requirements for different uses may in some cases conflict.

Canoeing on the Red Deer River

No rivers or reservoirs in the South Saskatchewan system are managed principally for recreational use. Some minimum water levels for recreation are recognized on certain irrigation and hydroelectric reservoirs and on Glenmore reservoir in Calgary. As long as there are no conflicts with the principal use, the reservoirs are

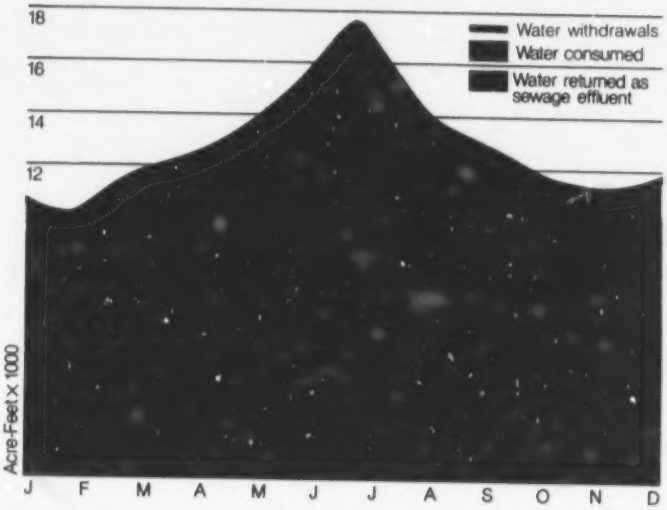
operated at these levels during the summer recreation season. Management of the river system to provide the most desirable conditions for recreation would impose restrictions on the diversion of water for other uses, on waste disposal, and on the operation of storage reservoirs.

5. MUNICIPAL & INDUSTRIAL USE

The use of water for municipal purposes involves withdrawing water from a source such as a river, canal, lake or well, treating it to ensure it meets public drinking water standards, and distributing it to residential, institutional, commercial, industrial and public users served by the municipal waterworks. Only the larger urban centres withdraw significant amounts of water, yet the withdrawals are not large relative to the flows of the major rivers on which these centres are located. Figure 4.1 shows an urban waterworks and sewer system; Figure 4.11 illustrates a typical seasonal pattern of urban municipal water use. On average, about 20% of the water withdrawn for municipal use is consumed; the remainder is returned to the river system as sewage effluent. Both withdrawals and consumption are greatest during the summer months, normally peaking during July.

The water shortages occasionally experienced in the larger urban centres generally result from the inability of the municipal waterworks system to treat and distribute sufficient water during periods of exceptionally high demand, rather than from a shortage of water at the source of supply. Some rural communities with less reliable surface or groundwater supplies occasionally experience water shortages at the source of supply.

Fig. 4.11 Municipal Water Use, Calgary (1983)



Industries in southern Alberta are not significant users of water. The majority of industrial establishments are situated in urban centres, and obtain their water and dispose of their effluent through municipal water and sewer systems. There are only a few larger water-using industrial plants that obtain their water from surface water sources and have their own water treatment and disposal facilities.

Because it is both convenient and economical, disposing of effluents from industrial plants and municipal sewage systems in rivers has been a generally accepted practice. It comes into question when the nature and volumes of the effluents are such that they interfere with the use of the water for other purposes.

6. WASTE DISPOSAL

The principal sources of contaminating substances found in the waters of the South Saskatchewan River system are municipal and industrial effluents, urban stormwater runoff and irrigation return flows. Contaminants are also carried to the rivers in surface runoff from natural, recreational and agricultural lands. The most significant of the contaminating substances found in the river system are pathogenic (disease-causing) bacteria and viruses, salts, nutrients, metals, organic compounds and suspended solids.

River water dilutes the concentration of these substances, and has the capacity to change their form and composition. These changes are brought about by physical and biological processes that take place in the water (instream processes) such as bacteriological decay, and assimilation by aquatic plants and animals.

The extent to which these instream processes can reduce the effects of the contaminating substance depends on what the substance is and how much there is, compared to the volume of water, the temperature and speed of the river, as well as the distance from the source of contamination and how long the substance has been in the water. Figure 4.12 shows how contaminants are handled by instream processes.

Pathogens

Disease-causing bacteria and viruses enter the river from various sources but mainly from municipal sewage effluent. These bacteria and viruses are adapted to living in warm-blooded organisms, and so they do not live long in river water.

however, their presence conflicts with the use of the rivers for contact recreation and for household use in its raw form. The types of bacteria and viruses found in sewage effluent can cause gastroenteritis or minor infections of the eyes, ears, nose or throat. Bacteria that cause salmonellosis, typhoid or cholera and viruses that cause poliomyelitis or infectious hepatitis may also occur. All municipal water supplies in Alberta are treated to meet Canadian drinking water standards. Common practice is to not drink untreated surface water in settled areas.

Salts

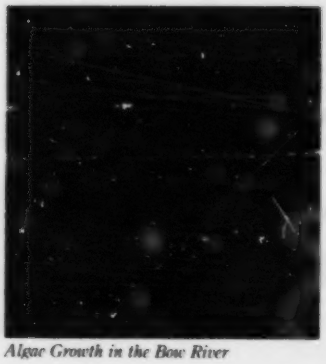
Calcium bicarbonate, the most common salt in the South Saskatchewan River system, reache the river primarily as a result of erosion of limestone in the upper reaches of the watershed. Sodium chloride and sodium sulphate come from natural sources, municipal sewage effluents and irrigation return flows. Since these salts do not react with any other substances, the only instream process that affects them is dilution. Water with a high salt content used for irrigation results in soil salinization and reduced crop yields. Extreme salt concentration can be harmful to livestock. Sulphates can cause gastrointestinal problems in humans and impart an unpleasant taste to drinking water. Current treatment technology does not remove sulphates from water.

Suspended Solids

Suspended solids, which include soil particles and larger organic materials, occur in surface runoff, municipal and industrial effluents, and urban stormwater. These solids are first diluted, then settle out of the water to form sediments on the river bottom. Suspended solids interfere with plant and animal life in the river, and turbid water is aesthetically unsuitable and can be unsafe for recreation.

Metals and Organic Compounds

Metals such as lead, zinc, copper, mercury, iron and manganese and organic compounds such as herbicides, pesticides and phenols, enter the rivers from all sources. Iron and manganese, the metals which occur in the greatest concentration, come principally from surface runoff as a result of erosion in the headwaters areas. Urban stormwater runoff is the principal source of lead. Contaminants such as mercury or the range of organic compounds common in more industrialized areas rarely occur at detectable levels in the South Saskatchewan River system. Most metals and organic compounds are taken up by aquatic plants and animals,



Algae Growth in the Bow River

which is the case in recent reports of high mercury levels in fish in the South Saskatchewan system.

Nutrients

The major nutrients, nitrogen, phosphorous and carbon, enter the rivers from all sources. In the South Saskatchewan system, the main source of the various forms of nitrogen and phosphorous is municipal sewage effluent. Most nutrients are processed instream by biological assimilation; some forms of nutrients are altered by bacteria in the river water, some are taken from the water by aquatic plants. The principal example of this process is the uptake of phosphorous and nitrogen by algae and aquatic weeds, which depend on these nutrients to sustain their growth. If other conditions for plant growth such as light, temperature and streamflow are adequate, an abundant supply of nutrients can produce prolific growths of algae and aquatic weeds, which are themselves a water quality problem. Heavy stands of weeds and algae can be unsightly, restrict the habitat of fish, make swimming unpleasant and boating and fishing difficult. During the hours of darkness, they deplete the dissolved oxygen in the water. When weeds and algae die and break free of their roots, they form unsightly floating masses which can clog water intakes, fish ladders and irrigation equipment. As they decay, they deplete the dissolved oxygen in river water and give an unpleasant taste and odor to public water supplies.

Dissolved Oxygen

The dissolved oxygen content of river water is one of the more important indicators of its quality. Oxygen is required to support the aquatic plants and animals in a river, and sustains the oxidation process by which bacteria break down organic matter. In a reach of river where there is not a lot of organic material getting into the water, the requirement for oxygen to break down this material – biochemical oxygen demand (BOD) – is not great, and dissolved oxygen in the river water is likely to be at its maximum. Where sewage effluent is discharged into the river, substantial amounts of organic material enter the water. The BOD is increased,

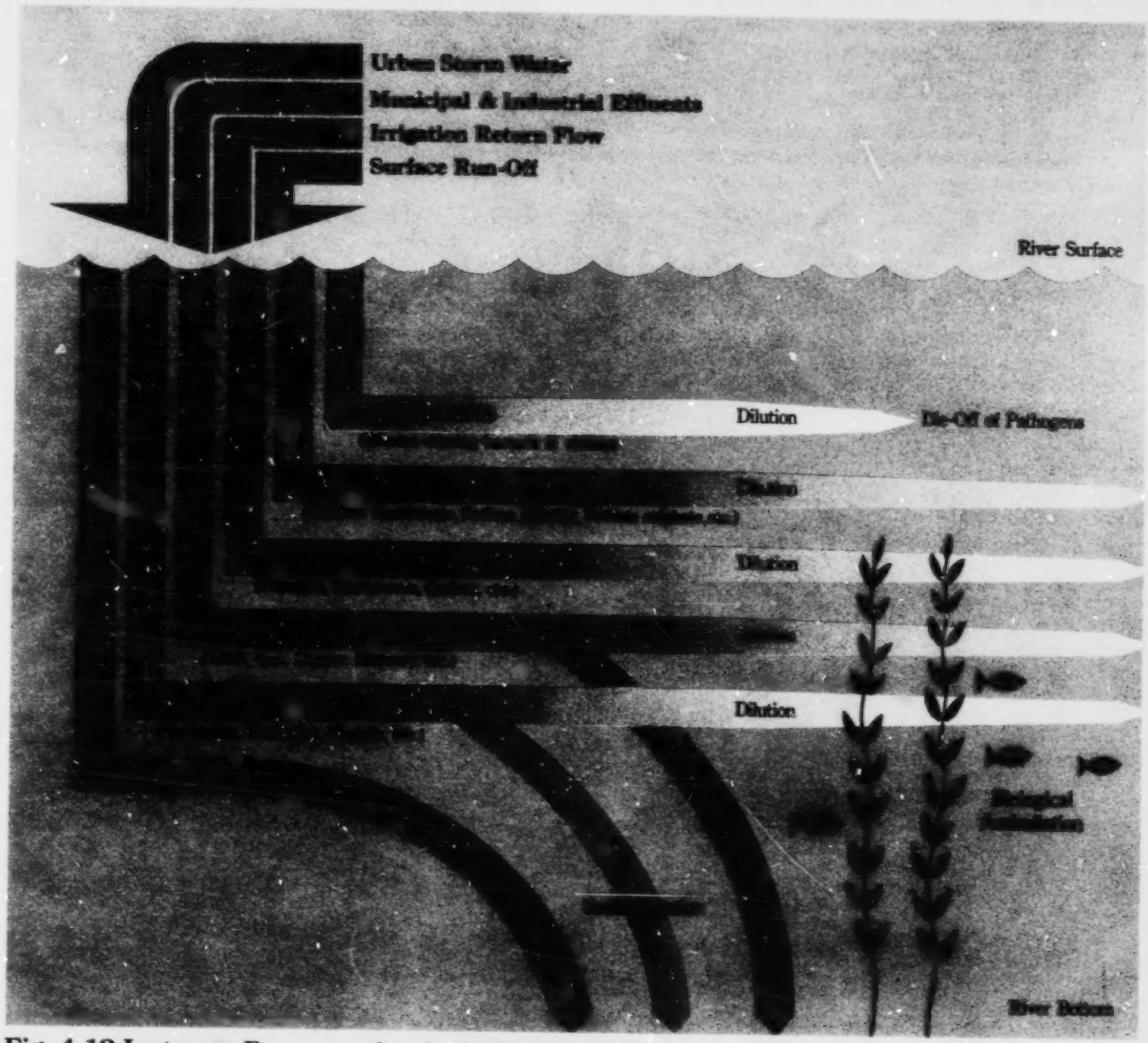


Fig. 4.12 Instream Processes for Assimilation of Waste

and the dissolved oxygen (DO) content of the water is reduced for a distance downstream from the outfall as oxygen is used up as the organic material is oxidized. As the water flows downstream, the DO content is continuously replenished by aeration and by the photosynthesis process of plants growing in the water. At some point downstream, if there are no further significant deposits of organic material, the DO content of the water can be expected to return to a level comparable to that upstream from the outfall. Figure 4.13 illustrates the changes that are likely to occur in the dissolved oxygen content of river water when sewage effluent is discharged into the river.

The dissolved oxygen content of river water can also vary significantly between day time and night time. During daylight hours, algae and other aquatic plants engage in photosynthesis, a process in which plants convert chemical compounds into carbohydrates and give off oxygen as a waste product. During the hours of darkness photosynthesis does not occur, but plants take oxygen from the water. Consequently, depending upon the abundance of plant life, the dissolved oxygen content of river water may be expected to undergo fluctuations similar to those shown in Figure 4.14.

When the dissolved oxygen content of river water is low, habitat conditions may become intolerable for some species of fish. If the dissolved oxygen level reaches zero (anoxic conditions) the general chemical quality of the water is unsuitable for almost all uses.

Controlling Contamination

A variety of management practices can be implemented to reduce the potential contaminants reaching a river, depending on the source. Surface runoff is not an easily controlled source of contaminants, however, adopting land use practices that reduce erosion in activities such as lumbering and agriculture gives some control. Retention ponds and settling basins can be built into urban stormwater sewer systems to reduce the amounts of suspended solids and organic materials discharged to rivers.

Industrial and municipal sources of effluents can be controlled more effectively. In some instances, industries can arrange to route their wastewater through a municipal sewage treatment plant. In others, where large volumes of wastewater are involved, where distance makes it uneconomical to transport wastewater to a municipal plant, or where a municipal plant is not designed to adequately treat an industry's wastewater, treatment facilities must be installed at the industrial site.

Municipal sewage treatment is commonly considered in terms of three levels of treatment: primary, secondary or tertiary. Primary and secondary levels of treatment are directed at reducing the quantities of suspended solids and the level of BOD in sewage effluent.

Primary treatment involves screening large materials and grit from the sewage, grinding solids to

Fig. 4.13 Dissolved Oxygen and Biochemical Oxygen Demand

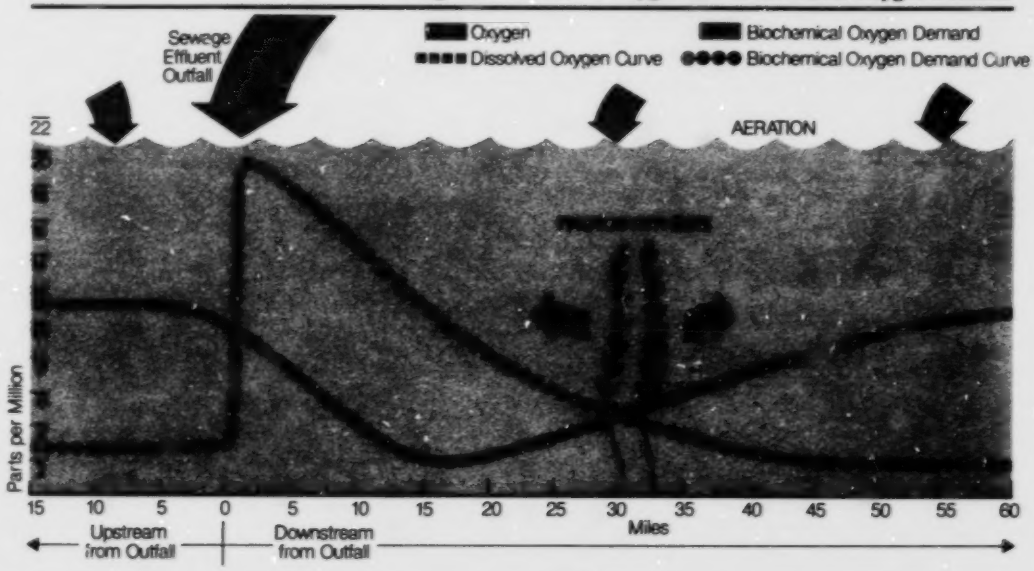
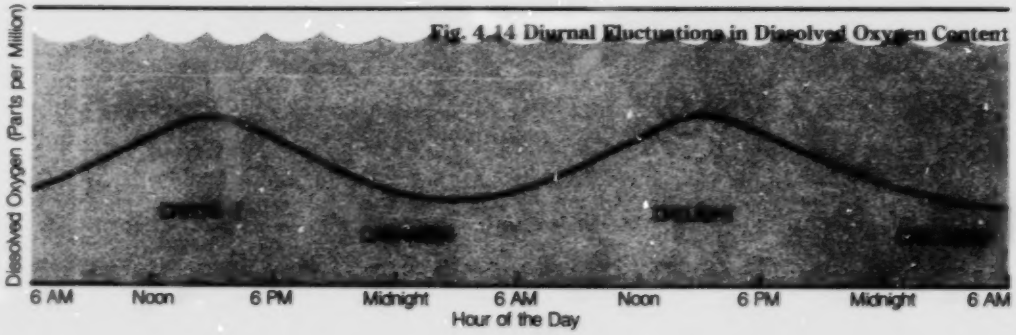


Fig. 4.14 Diurnal Fluctuations in Dissolved Oxygen Content



reduce their size and the removal of some of these solids in settling tanks. Secondary treatment involves combining micro-organisms with sewage in the presence of oxygen. The micro-organisms feed on and thus reduce the amount of organic material in the sewage. The wastewater is then clarified by removing the resulting biological solids in settling tanks. These processes remove 85% to 95% of the organic materials and suspended solids (sediments) from the sewage. Secondary treatment also removes some of the nitrogen, phosphorous, and heavy metals, and up to 95% of the pathogens. The further removal of such contaminants requires some type of tertiary treatment that reduces the level of a particular contaminant.

The contaminants in municipal sewage which are of greatest concern in the South Saskatchewan system and which may not be adequately controlled by conventional primary and secondary treatment are pathogens; ammonia, which is toxic to fish; and phosphorous, the most readily controlled of the nutrients that promote abundant algae and aquatic weed growth.

Ninety-nine percent of the pathogenic bacteria and viruses can be removed by disinfection before the effluent is discharged. There are three known treatment processes that are effective: chlorination, ozonation and ultraviolet radiation. Some of the compounds formed as

Secondary aerator at Calgary's Bonnybrook Sewage Treatment Plant

by-products of the chlorination and ozonation processes have been found to be carcinogenic, although the chronic effect on human health of low levels of the compounds produced is poorly understood. Although less is known about the potential side-effects of the ultraviolet process, it produces fewer toxic compounds. Some municipal sewage treatment plants in the basin are required to disinfect their sewage effluent because they discharge too close to the municipal water supply intakes of downstream communities or to recreation areas.

Ammonia and nitrates can be removed from sewage effluent by advanced treatment processes called nitrification, in which certain bacteria oxidize ammonia to nitrates, and denitrification, in which another type of bacterium oxidizes the nitrates to elemental nitrogen. The only use of advanced or tertiary treatment to remove phosphorus from sewage effluent in the basin is in Calgary, where an alum precipitation process has been used since early 1983.

7. LEGAL & INSTITUTIONAL ARRANGEMENTS FOR WATER MANAGEMENT

Water Quantity

The use and management of water in the basin is regulated through arrangements established by the provincial government, primarily under the Water Resources Act and the Clean Water Act. As well, an agreement with the other prairie provinces and the federal government establishes the quantity of water Alberta is entitled to use.

Water Resources Act

Anyone wishing to divert, store or otherwise establish a right to use surface water in Alberta must obtain a licence issued by the Department of Environment under the terms of the Water Resources Act.

In general, the system of licencing operates in accordance with the principle of "prior allocation", which means that the priority of one water user over another is determined by the date upon which they applied for a licence, regardless of how they use the water. With the approval of the Minister of Environment, an applicant can acquire the licence of another user with an earlier priority, but lower precedence, but must compensate the user whose licence is cancelled for any loss or damage he sustains as a result. The order of precedence of use that applies in such transactions is: domestic, municipal, irrigation and other agricultural purposes, industrial, water power, other like purposes, impoundment for various purposes, and use of the water in its natural state for conservation, recreation, or the propagation of fish and wildlife.

In periods of emergency, the government can suspend any licences and designate the purposes for which, and the quantities in which, water may be used. The water users whose licences are suspended are entitled to compensation for losses they incur. Water that has not been allocated can be reserved from use and priorities can be set for the future allocation of that water.

The operation of the water control structures on

the river system is the responsibility of the owners of the structures. TransAlta Utilities holds a number of licences that allow the firm to regulate the flow in the upper Bow River and a number of its tributaries (Cascade, Spray, Kananaskis, Ghost) for the purpose of generating electricity, subject to certain conditions set out in the licences pertaining variously to reservoir levels, releases for irrigation use downstream and, in the case of Bearspaw, regulation of flow in the Bow through Calgary to minimize icing conditions. The city of Calgary, through the licenced operation of its Glenmore Dam, regulates the flow of the lower Elbow River within the city. The other major water control structures on the river system, with one exception, are owned and operated by Alberta Environment. These include Dickson Dam on the Red Deer River, the Western Irrigation District (WID) and the Carseland-Bow Headworks on the Bow River, the Lethbridge Northern Irrigation District (LNID) and the Waterton-St. Mary Headworks on the Oldman System, and the Squaw Coulee and the Little Bow diversion works on the Highwood River. The exception noted is Bassano Dam on the Bow River, which is currently owned and operated by the Eastern Irrigation District. As noted earlier, discussions are underway for the eventual transfer of these headworks to Alberta Environment.

8. THE MASTER AGREEMENT ON APPORTIONMENT

The amount of water that Alberta can consume or otherwise withhold from the flow of the South Saskatchewan River system is limited by the terms of the "Master Agreement on Apportionment". This agreement was signed by Canada and the provinces of Alberta, Saskatchewan and Manitoba in 1969. The agreement allows Alberta to "divert, store or consume" from the river system each year, a volume of water equal to one-half of the natural flow of the South Saskatchewan River at the Alberta/Saskatchewan boundary. The remaining volume of flow must be allowed to pass downstream into Saskatchewan. The exception to that general rule is that Alberta is entitled to "divert, store or consume" a ***minimum*** of 2.1 million acre feet in any year, provided that at all times during the period that Alberta is diverting, storing or consuming this quantity of water, a flow of 1500 cubic feet per second (cfs) is maintained at the Saskatchewan border. The effect of this exception is that during years when the volume of natural flow is less than 4.2 million acre feet (a rare occurrence) Alberta may pass less than one-half to Saskatchewan. However, because it is not possible to forecast the total natural flow for the year with confidence, it means, in effect, that Alberta must ensure that there is a continuous flow of at least 1500 cubic feet per second at the boundary during the period from May to October when water is being diverted, stored or consumed in large quantities.

The agreement allows Alberta the option of considering the Red Deer River and the South Saskatchewan River (which meet in Saskatchewan a few miles downstream from the Alberta/Saskatchewan boundary) as separate rivers or as one river for purposes of apportionment. Alberta has opted to consider the two rivers as one.

The flow of these rivers is monitored and the natural flow at the boundary is estimated by the Prairie Provinces Water Board. This board is a federal-provincial agency established by the signatories to administer the Master Agreement on Apportionment.

Alberta Environment manages the river flows in the South Saskatchewan system and develops operating arrangements with the owners of water control structures to maintain adequate streamflows to fulfill Alberta's commitment to Saskatchewan.

Water Quality

The Clean Water Act

The use of surface water bodies for the disposal of wastewater is managed by Alberta Environment under the Clean Water Act. The province requires that all municipalities provide both primary and secondary sewage treatment. This is managed primarily through the provision of funds for constructing sewage treatment plants; virtually all of the municipal sewage treatment plants in the basin have been funded in part by the province through the Municipal Water Supply and Sewage Treatment Grant Program. Alberta Environment sets design standards for sewage treatment plants so that they will produce an effluent that meets the standard of 25 mg/l of suspended solids and BOD. Only plants that can meet this standard are approved for funding under the grant program.

Industrial wastewater may be treated and discharged directly by industries under licence from Alberta Environment or may be discharged through municipal sewage treatment plants. The province has developed wastewater management guidelines for industries, based on the "best practicable technology" for adequate treatment. Best practicable technology is defined as a

treatment method that is in general commercial use and that is financially feasible for an industry to implement. Licences to operate a treatment facility issued to an industry define allowable concentrations for different components of the effluent, set limitations on discharge of the effluent, and specify monitoring and reporting requirements.

The Alberta Surface Water Quality Objectives are a consideration in designing and approving municipal and industrial wastewater treatment plants and in setting conditions in licences issued for the operation of a plant. Although these objectives and criteria have no legal standing, they are used to determine if the established effluent standards are effective in maintaining acceptable water quality in receiving streams. Where health or environmental considerations merit it, the province may require more sophisticated treatment than is generally the rule to reduce the occurrence of particular contaminants. For example, advanced phosphorus removal to a standard of one mg/l is required of the city of Calgary's municipal sewage treatment to control weed and algae growth in the Bow River.

Water quality conditions are monitored in three ways: continuous collection of data on major pollutants for the larger rivers, annual inspection of sewage treatment plants, and special sampling programs for evaluating problems that regular monitoring does not assess.

If a licenced discharge is violating the standards set out in the licence, Alberta Environment will direct that remedial measures be taken. Legal action is initiated if these remedial measures are not implemented.

Currently, there are no inter-provincial regulations governing the quality of river water flowing from Alberta into Saskatchewan. However, the Prairie Provinces Water Board has agreed that water quality standards should be established for the South Saskatchewan and Red Deer rivers at the Alberta/-Saskatchewan boundary.

Financial Arrangements for Water Management

Generally, the government does not levy a charge for the use of water. The exception to this rule in the South Saskatchewan River Basin is the royalty paid by TransAlta Utilities which is based on the amount of electricity generated by its hydro plants.

Irrigators who own and operate their own works for diverting water are licenced under the Water Resources Act. They pay a nominal licencing fee to partly offset the cost of administering licences, but they do not pay for the water they use. Irrigators who obtain their water from an irrigation district are not licenced. The irrigation district, as the licenced water user, pays a nominal licencing fee but does not pay for the water that it uses. The irrigators served by an irrigation district pay a "water rate" levied by the district to provide funds to meet the operation and maintenance costs of the district and the district's portion of capital costs shared with the province. This water rate is levied as a per-acre assessment and is not directly related to the amount of water that the irrigator uses.

Urban centres and communities with municipal water and sewer systems levy charges against those served by the system to meet the costs of treating and delivering water and collecting and treating sewage. Charges to metered users are based on the amount of water used; unmetered users are charged a flat rate. In either case, the charge is not for the water, but for the services provided. Neither the users nor the utility pay for the water used or for depositing sewage effluent in the river.

The provincial government provides financial assistance for water management through several shared cost programs. The largest of these programs provide grants to municipalities for construction of water and sewage systems and to irrigation districts for construction and rehabilitation of irrigation works. In addition, Alberta Environment has assumed complete responsibility for the construction, operation and maintenance of the headworks system that supplies water to most of the irrigation districts and a number of rural communities.

Strategies

The basic question at issue in developing strategies for water management in the South Saskatchewan River Basin is **"What use do Albertans wish to make of the water in the river system in future years?"** Many choices confront us. More water could be allocated for irrigation to increase agricultural production and farm incomes. More could be allocated for recreation or the maintenance of fish habitat to increase recreational opportunities. More could be allocated for peak hydro generation to conserve fossil fuels and ensure firm supplies of energy. More could be allocated for use in one basin than another in the interests of regional development. More could be reserved from allocation to hedge against an uncertain future.

The Need for Strategic Planning

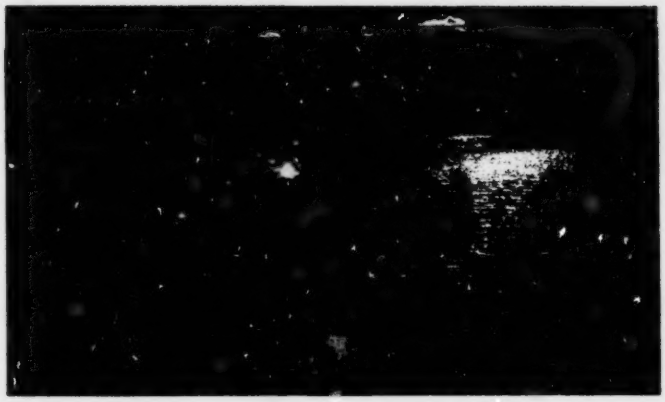
In the Introduction it was noted that significant future development in irrigated agriculture, industry, and urban growth would require more intensive management of the supply and use of water in the basin. "More intensive management" could mean more storage and works, improved management and control of water in irrigation use, improved or alternative methods of sewage treatment and disposal, strict limits on the amount of water that can be consumed from the Red Deer, Bow, and Oldman Rivers (or, conversely, how much water each must contribute to Alberta's apportionment obligation), or some combination of the foregoing. The realization that "more intensive management" might well be needed signals a shift in our understanding of the planning and management requirements of the South Saskatchewan system.

In the past, planning could have a narrower focus, concentrating on achieving specific objectives in smaller regions of the basin with specific management measures. Sub-basins could be treated in isolation, since management to achieve certain objectives in one sub-basin still left a sufficient supply of water to meet the needs in others.

Recent experience has convinced us that this is no longer true. With the Master Agreement on Apportionment in 1969 came the formal obligation that Alberta generally must provide at least 50% of the natural flow annually to Saskatchewan; although Alberta was assured of the right to retain at least 2.1 million acre feet of water in any year. The natural supply available for future consumption had been cut in half. The Prairie Provinces Water Board, the intergovernmental body that administers the Master

Agreement on Apportionment, is in the process of establishing interprovincial water quality requirements for the Red Deer River and for the South Saskatchewan River. These will dictate what the quality of the water flowing in these rivers must be at the points where they cross the Alberta/-Saskatchewan boundary.

In the 1970's planning programs and hearings took place that addressed the questions of flow regulation on the Red Deer and storage, principally for irrigation, on the Oldman. Through these processes and in light of the stipulations of the Apportionment Agreement, the understanding developed that water use, management and planning in each of the sub-basins are inextricably linked with the others. In 1976 Alberta Environment recognized that in order to ensure "the most beneficial use of the water to which Alberta is entitled, the flow of...the Bow, the Oldman and the Red Deer must be managed equitably and **in concert,** (emphasis added)". The Oldman River Basin Study Management Committee concluded in their report in 1978 that to support the projected ultimate level of irrigation development in that basin would place greater limits on the use of water in the Bow and Red Deer river basins because of the requirement to maintain flow into Saskatchewan.



Development of irrigation in one basin, then, becomes contingent upon decisions pertaining to the use and management of water in the other basins.

Thus the need for a water management strategy for the South Saskatchewan River Basin has become apparent. We can no longer implement significant water use or management undertakings in any part of the South Saskatchewan basin without seriously affecting present and future use in the entire basin. Were we to proceed as in the past to plan specific projects to meet specific needs, we would eventually evolve a "strategy" by default or administrative decision. While such specific developments might be very worthwhile, the resulting water use and management pattern might not be what the people of Alberta want or need and there might remain little flexibility to change this pattern. To ensure the orderly development, protection and beneficial use of our water, Alberta Environment instituted the South Saskatchewan River Basin Planning Program to develop a framework management plan for the basin. To achieve this objective, data bases and a planning process were developed to assist the government in considering a number of strategic options and in choosing what overall direction water use and management in the basin would take.

Developing Strategies

A strategy is a general, usually long-term plan of action to achieve a stated objective or set of objectives. The elements of any strategy are: objectives, means of achieving these objectives, and estimates of effectiveness, possible negative consequences and costs. There could be a number of different strategies for achieving even a single objective. When there are a fairly large number of objectives of varying importance, as is the case in the South Saskatchewan River basin, a large number and rich variety of strategies might be suggested.

Developing potential strategies for water use and management requires that we know and understand the essential components of the system: the amount and timing of the water supply; established and potential patterns of water use; the Master Agreement on Apportionment, which limits Alberta's share of the water; the objectives we have already set for water use; and present policy on water use and management that support these objectives. We have already looked at the first three components; it is now time to look at objectives and policy.

Policies And Objectives

The Government of Alberta's principal water management objective is:

> Alberta's water resources are to be managed in support of the economic and social objectives of the Province.

This objective, which establishes the purpose for the use and management of water in the basin, provides both the basis for the development of strategies for the future and a perspective from which to analyze the probable effectiveness and evaluate the likely consequences of implementing those strategies.

Two levels of economic and social objectives have been identified: the provincial government's broad, general objectives; and more specific objectives that pertain to various social, economic, environmental and cultural sectors, and that are influenced by or have an influence on the allocation, use and management of water in Alberta. The provincial government's general economic and social objectives are shown in Fig. 5.1.

Water management can make a significant contribution toward the attainment of these general objectives. Of particular note are: the role irrigated agriculture plays in diversifying the economy and facilitating regional economic growth; the contribution that a reliable supply of good quality water makes to improving the quality of life; and the importance of ensuring that water supplies are not used wastefully or damaged by pollution.

Sectoral Objectives

Specific objectives which contribute to the province's achievement of its general objectives have been identified in nine important social, economic, environmental and cultural sectors. The sectors and their objectives are listed in Figure 5.2.

1. To provide a diversified provincial economy which is less dependent on the sale of unprocessed resources, particularly non-renewable resources.
2. To encourage balanced economic growth throughout Alberta.
3. To build a strong private sector by strengthening small and locally-controlled businesses within Alberta.
4. To develop a skilled workforce by upgrading the job skills of Albertans to achieve higher productivity, greater incomes and more job satisfaction.
5. To obtain a competitive advantage in the provision of certain goods and services by capitalizing on the province's natural advantages and building on strengths.
6. To improve the quality of life in Alberta.
7. To ensure that provincial resources are not wasted, damaged, or polluted.

Fig. 5.1 General Economic and Social Objectives

These specific objectives will help us to establish methods to analyze and measure the effectiveness of specific water management strategies and to evaluate the likely consequences of implementing one strategy as opposed to another.

Water Use Objectives

Water use objectives have been identified through contact and discussion with public groups throughout the South Saskatchewan basin. For more than two years Alberta Environment public participation co-ordinators have been in contact with local governments, planning commissions, water user groups, and recreational and environmental organizations. Over 200 groups have been briefed on the South Saskatchewan basin and the planning program. These groups have identified their "Water Use Objectives", the objectives and methods of water use and management that they would like to see in the basin. These objectives have been compiled in water use objective reports which establish a general view of public interests.

Figure 5.3 provides an overview of the objectives more commonly expressed by people in various parts of the basin. While these water use objectives are **initial** expressions of public priorities or interests, and are not the last word, they indicate the relative importance that people or groups attach to those interests. As is apparent from Figure 5.3., the water use objectives that people have expressed are consistent with the government's general objectives and with the more specific objectives the government has for the various social and economic sectors.

Water Management Policy

Over the years a body of policy has emerged that provides the basis for water management as it is practiced by the government in the South Saskatchewan River Basin. These policies can be summarized under four categories: general water management, water supply, water use, and water quality. In considering possible strategies for future water management, we should think of these policies in two ways:

1. They are an expression of current strategies for managing water in support of the province's economic and social objectives.
2. They are variables that may have to be changed in order to put future strategies into use.

Fig. 5.2

Sectoral Objectives

Community Development Objectives	To ensure that communities have opportunities to develop economically and improve their quality of life
Industrial Development Objective	To encourage development of processing and manufacturing industries that are efficient and internationally competitive
Agricultural Development Objectives	**a.** To improve net farm incomes **b.** To add to the viability of rural communities **c.** To provide stability and security in the farm economy **d.** To increase agricultural production in part through increases in the productive capability of agricultural land **e.** To increase opportunities for family farm development **f.** To promote the creation of secondary agricultural industries
Energy Development Objectives	**a.** General Objective: To ensure the long term adequacy of energy supply for Alberta's needs. **b.** Electric Energy Objectives: i. To ensure that electric energy is provided at rates which are equitable and reasonable for both the customers of and the investors in electric utilities ii. To ensure that the development and operation of hydro and other electric energy occurs in an economic, orderly and efficient manner
Tourism Objective	To develop tourism so that it contributes to balanced regional growth and diversification of the economy
Recreation Objective	To promote and encourage orderly development of recreational activities and facilities for the betterment of the people of Alberta
Fish Management Objectives	**a.** To ensure that fisheries populations are protected from severe decline and that viable populations are maintained **b.** To maintain the capability of surface water for fish production
Wildlife Management Objective	To ensure that wildlife populations are protected from severe decline and that viable populations are maintained
Environmental and Historical Resources Management Objectives	**a.** To promote a desirable balance between economic development and environmental protection **b.** To minimize irreversible environmental disturbances **c.** To avoid unnecessary impact on historical resources, to preserve the most important historical resource sites whenever feasible and to promote the recovery of information from those sites which cannot be preserved

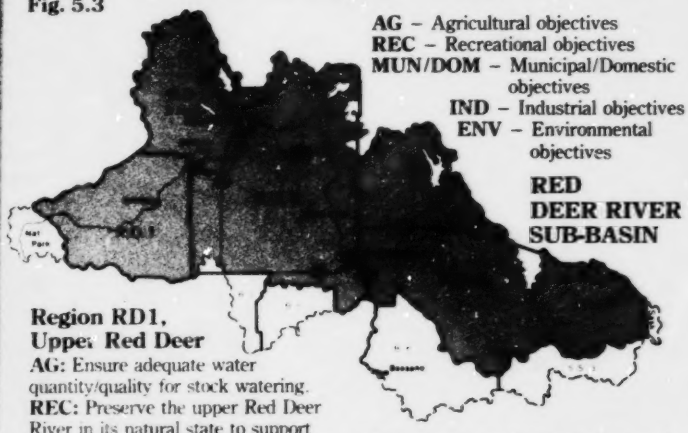
General Water Management Policies

There are four general policies for water management in the South Saskatchewan River Basin:

1. Promote orderly development of water resources.
2. Take action to prevent supply shortages, water pollution and user conflicts.
3. Manage each major river basin as a single unit.
4. Satisfy the provisions of the Master Agreement on Apportionment, 1969.

SUMMARY OF WATER USE OBJECTIVES

Fig. 5.3



AG – Agricultural objectives
REC – Recreational objectives
MUN/DOM – Municipal/Domestic objectives
IND – Industrial objectives
ENV – Environmental objectives

RED DEER RIVER SUB-BASIN

Region RD1, Upper Red Deer

AG: Ensure adequate water quantity/quality for stock watering.
REC: Preserve the upper Red Deer River in its natural state to support white water boating; ensure adequate water quality to support fishing and camping.
MUN/DOM: Provide an adequate supply of good quality water; flood protection (Sundre); adequate sewage treatment system.
IND: Sufficient water to support the oil and gas industry.
ENV: Preserve the natural aesthetics of the region; watershed protection; maintain water quality for fish habitat.

Region RD2, David Thompson Country

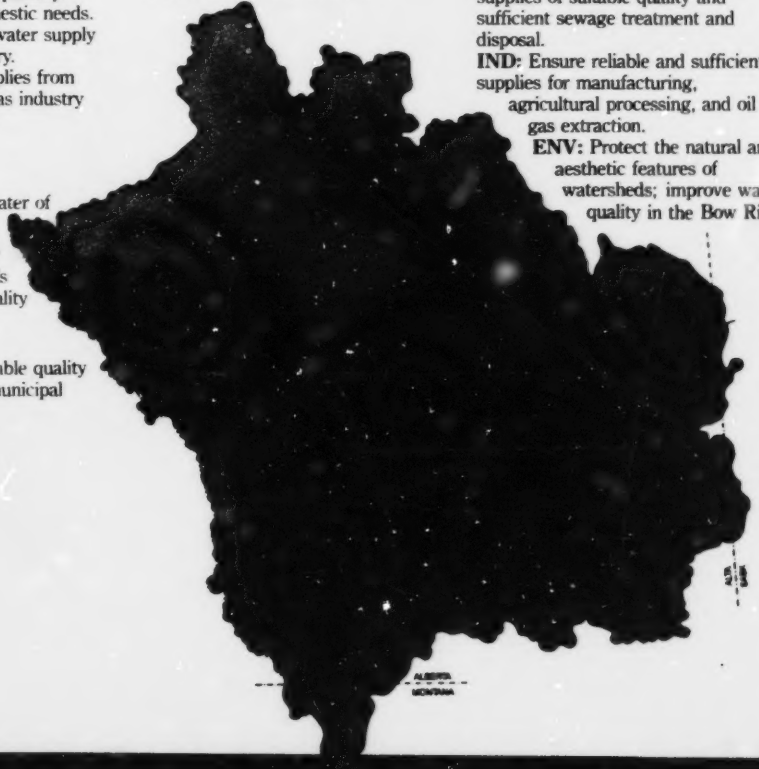
AG: Provide adequate drainage to bring more agricultural land under cultivation; provide flood control on the Medicine and Blindman rivers.
REC: Provide adequate shoreline management and water quality for rivers; ensure continued control of water levels in Gull Lake and adequate water quality in Gull and Sylvan lakes for recreation.
MUN/DOM: Sufficient quantity/quality for municipal/domestic needs.
IND: Provide sufficient water supply for the oil and gas industry.
ENV: Protect water supplies from pollution by the oil and gas industry and agricultural sources.

Region RD3, The Parklands

AG: Provide sufficient water of suitable quality to support private irrigation.
REC: Stabilize lake levels and provide sufficient quality for recreation.
MUN/DOM: Ensure adequate supplies of suitable quality water to meet growing municipal needs.
IND: Provide sufficient water to meet the present and future needs of the petrochemical industry; ensure adequate industrial effluent treatment to protect downstream users.
ENV: Protect shorelines and streams from agricultural pollution; protect water quality in lakes and streams.

Region RD4, The Plains

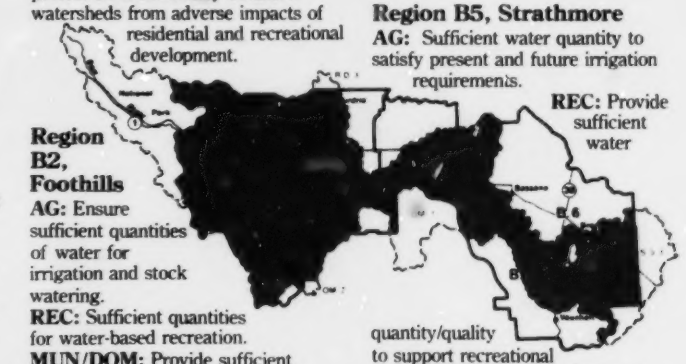
AG: Provide sufficient water of suitable quality for stock watering and irrigation development.
REC: Develop reservoirs to meet recreational needs; manage existing reservoirs to meet recreational as well as other needs.
MUN/DOM: Ensure a reliable water supply of sufficient quality to meet municipal/domestic needs.
IND: Provide sufficient water of suitable quality to promote industrialization and support the Sheerness thermal plant.
ENV: Ensure the protection of waterfowl and wildlife habitat.



BOW RIVER SUB-BASIN

Region B1, Upper Bow

REC: Operate hydro to accommodate recreational needs in Ghost Reservoir, the Bow and Kananaskis rivers.
MUN/DOM: Provide reliable and sufficient supply and quality for municipal/domestic use.
ENV: Provide sufficient quantity to maintain fisheries in the Bow and Kananaskis rivers; maintain water quality downstream from Canmore; protect environmentally sensitive watersheds from adverse impacts of residential and recreational development.



Region B2, Foothills

AG: Ensure sufficient quantities of water for irrigation and stock watering.
REC: Sufficient quantities for water-based recreation.
MUN/DOM: Provide sufficient water supplies of suitable quality for municipal/domestic purposes.
IND: Ensure adequate supplies for future industrial growth.
ENV: Maintain the integrity of the Highwood and Sheep rivers; minimize flood damage and ensure controlled flows along the Sheep River.

Region B3, Rocky View

AG: Sufficient quantities for irrigation and stock watering.
REC: Develop small reservoirs for recreational use; ensure sufficient water quantity and quality for recreation.
MUN/DOM: Ensure sufficient supplies of suitable quality and sufficient sewage treatment and disposal.
IND: Ensure reliable and sufficient supplies for manufacturing, agricultural processing, and oil and gas extraction.
ENV: Protect the natural and aesthetic features of watersheds; improve water quality in the Bow River.

Region B4, Calgary

REC: Utilize the Bow River for recreation.
MUN/DOM: Ensure sufficient water quantity and quality from the Bow and Elbow rivers for municipal/domestic use; utilize the Bow River as a receiving stream for treated sewage effluent and the discharge of storm water runoff.
ENV: Preserve the fisheries and wildlife habitat of the Bow and Elbow rivers.

Region B5, Strathmore

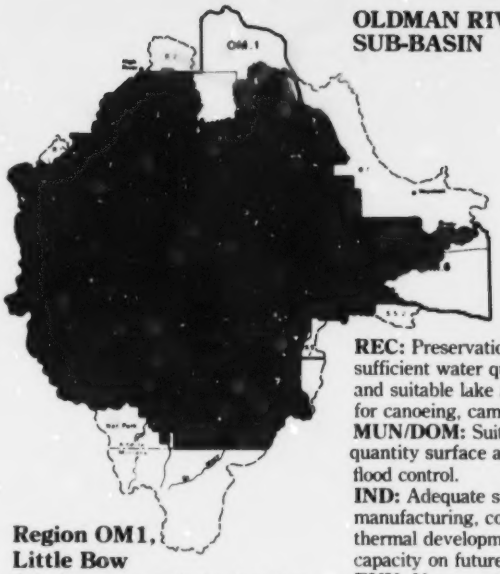
AG: Sufficient water quantity to satisfy present and future irrigation requirements.
REC: Provide sufficient water quantity/quality to support recreational activities on Eagle, Deadhorse and Severn lakes, Delacour Reservoir and Serviceberry Creek.
MUN/DOM: Ensure supplies of suitable quality for municipal/domestic uses.
ENV: Improve water quality in the Bow River downstream from Calgary and within the WID headworks and main canal system; provide sufficient water quantity/quality to support wildfowl habitat.

Region B6, Brooks

AG: Provide an assured and reliable supply of water for irrigation.
REC: Assured supply of suitable quality water in Lake Newell and Crawling Valley for recreational use.
MUN/DOM: Assure sufficient water quantity/quality for municipal/domestic use.
ENV: Provide reliable water quantity to maintain and enhance wildfowl habitat; improve water quality in the Bow River downstream from the city of Calgary.

Region B7, Vauxhall

AG: Ensure reliable and sufficient supplies for irrigation expansion in the BRID.
REC: Sufficient supplies and levels in lakes and reservoirs for recreational use.
ENV: Ensure sufficient water quantity and quality in the Bow River for fish.



OLDMAN RIVER SUB-BASIN

Region OM1, Little Bow

AG: Adequate supply for irrigation development and stock watering; sufficient instream flow to dilute return flows.
REC: Sufficient quantity/quality in lakes and reservoirs for recreation.
MUN/DOM: Assured supplies of suitable quantity and quality; adequate flows for effluent dilution.
IND: Suitable water levels in McGregor and Travers reservoirs for thermal coal development; sufficient supplies to accommodate industrial growth.
ENV: Adequate instream flows, suitable lake levels and water quality for fish and wildlife.

Region OM2, Willow Creek:

AG: Adequate supply of surface and groundwater for stock watering; sufficient supply for irrigation expansion along Willow Creek and the LNID main canal.
REC: Suitable quantity/quality in Chain Lakes and Willow Creek for recreational use.
MUN/DOM: Assured supplies of suitable quality. (Claresholm and Granum have had problems.)
IND: Assured supplies for orderly industrial development.
ENV: Adequate water quality/flows in Willow Creek and levels in Chain Lakes to protect the sports fishery and wildlife habitat.

Region OM3, Upper Oldman

AG: Assured supplies of suitable quality for stock watering and irrigation.
REC: Preservation of natural areas; sufficient water quantity and quality, and suitable lake and reservoir levels for canoeing, camping and fishing.
MUN/DOM: Suitable quality and quantity surface and ground water; flood control.
IND: Adequate supplies for manufacturing, coal production and thermal development. Develop hydro capacity on future reservoirs.
ENV: Upper watershed preservation; preserve spawning areas; preserve the Oldman as a "wild river"; adequate lake levels for fish, waterfowl and wildlife.

Region OM4, Central Oldman:

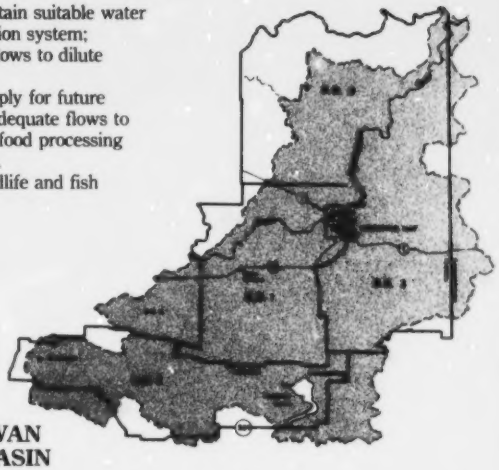
AG: Adequate supplies for present and future irrigation and stock watering; no irrigation "failure" criteria.
REC: Develop and expand recreational options; suitable water quality and reservoir levels.
MUN/DOM: Assured supplies of adequate quality; instream flows sufficient for effluent dilution.
IND: Assured supply for the expansion of food processing and other industries.
ENV: Preserve fish and wildlife habitat; adequate flows.

Region OM5, Waterton - Belly - St. Mary's:

AG: Adequate flows and supplies for livestock watering and future irrigation expansion; review the 18" water duty.
REC: Suitable reservoir levels, instream flows and water quality for recreation.
MUN/DOM: Assured supplies of suitable quality; adequate flows to absorb treated sewage effluent.
IND: Sufficient quantity/quality for food processing; adequate instream flows for effluent dilution.
ENV: Preserve spawning areas, fish and wildlife habitat, the watershed and the area's aesthetic characteristics.

Region OM6, Eastern Oldman:

AG: Sufficient water supply for present and future irrigation and stock watering needs, especially in the St. Mary's system; no irrigation "failure" criteria.
REC: Suitable water quality for swimming, boating and fishing; provide public access to area reservoirs; maintain reservoir levels for recreational use.
MUN/DOM: Maintain suitable water quality in the irrigation system; adequate instream flows to dilute sewage effluent.
IND: Adequate supply for future industry; maintain adequate flows to dilute effluent from food processing and other industries.
ENV: Preserve wildlife and fish habitat.



SOUTH SASKATCHEWAN RIVER SUB-BASIN

Region SS1, Northwestern South Saskatchewan:

AG: Irrigation expansion within the SMRID; new development between the South Saskatchewan River and Forty-Mile Coulee from Bow Island to Seven Persons; north of the South Saskatchewan River to the east of the BRID and south of the EID; east of the EID and south of the Suffield Military Experimental Range.
REC: Access to reservoirs; water levels maintained suitable for recreational use; suitable water quality in the South Saskatchewan River.
MUN/DOM: Assured supplies of suitable quality surface and groundwater.
IND: Adequate supplies for industrial development; oil, gas and coal production; thermoelectric energy.

Region SS2, Southwestern South Saskatchewan:

AG: Assured supplies of suitable quality for stock watering and irrigation expansion; review the 18" water duty.
REC: Allow recreational development on reservoirs; stabilize lakes and maintain suitable water quality and levels for recreational use.
MUN/DOM: Assured supplies of suitable quality surface and ground water; suitable water quality and levels in irrigation reservoirs.
IND: Adequate supplies for industrial development.
ENV: Suitable water quality for wildlife and waterfowl; stabilize lake levels for waterfowl production.

Region SS3, Eastern South Saskatchewan:

AG: Assured supplies for irrigation development and stock watering.
REC: Weir on the South Saskatchewan River to stabilize levels and flows for recreation; stabilize lake and reservoir levels; suitable water quality.
MUN/DOM: Assured supplies of surface and groundwater; suitable quality.
IND: Adequate supplies and instream flows for industry, hydro and thermal generation.
ENV: Stabilize lake levels and provide for adequate instream flows; suitable quality to support warm water fish species and wildlife.

P.F.R.A. Photo

Policies on Water Supply, Use and Quality

The government also has specific policies on water allocation and use, and on water supply and water quality management. These are summarized in Fig. 5.4.

Developing a Strategy: The Implications

Management of the Red Deer, Bow, Oldman and South Saskatchewan rivers "in concert" is necessary and desirable, but developing a plan to meet this goal is neither simple nor easily achieved. To develop a strategy requires that we identify those objectives we wish to meet with water management, then that we **choose** our priorities among them and how we intend to accomplish them. We are faced with the question of determining how we want to formulate our social and economic future, at least insofar as it is dependent on water use and management. This is an open question. Its answer will depend on our reflecting corporately on our **values** and, through our decision-makers, choosing a strategy that best reflects them.

Planning as a technical exercise provides information about the best way to accomplish an established goal. Strategic planning plays a different role. It is aimed at assisting participants to appreciate how a physical system functions, how the supply regime, uses and demands, and the water management to support them interrelate and affect the accomplishment of various sets of social and economic goals. Such planning provides a basis for analyzing and evaluating the effects of one strategy as opposed to another. It cannot, nor does it, recommend a "best" or "optimal" strategy. Such planning helps us to understand and consider the alternatives that are open to us, and to choose wisely the path we wish to follow.

The process of reviewing and identifying objectives implies that we will have to step back and critically assess established values and assumptions. We may choose to retain our present objectives or alter them. Either way we become aware that values and objectives are no longer comfortable "givens", that we will have to keep examining them as water use and management develop further in the South Saskatchewan basin. We might prefer well established, unquestioned objectives, and straightforward, readily available answers about how to achieve them. However, the complex interrelationships among the sub-basins of the South Saskatchewan do not permit the luxury of simple answers. If we understand the system, we can make more informed choices, appreciating more completely their potential effects and impacts. Then we will be able to effectively guide the use and management of the South Saskatchewan system and be better able to adjust to the changing requirements of our society in the years to come.

Scenarios

In Chapter 7 of this report a number of strategic options are presented in the form of scenarios. Each scenario addresses an objective or set of objectives and illustrates some of the water management and policy options that could be implemented to contribute to the achievement of those objectives. The scenarios are, therefore, expressions of the various strategies that could be pursued. They are designed as an aid in addressing the question posed at the ouset of this chapter: what use do Albertans wish to make of the water in the river system in future years? The answers to this question are an essential consideration in establishing a water use and management strategy for the South Saskatchewan River Basin.

Chapter 6 explains how the scenarios in this report were developed and analyzed, and how they can be used to understand the complex issues and trade-offs involved in developing a water use and management strategy.

Fig. 5.4

WATER MANAGEMENT POLICY SOUTH SASKATCHEWAN RIVER BASIN

Water supply

1. Implement measures to reduce the adverse effects of variations in the natural water supply.
2. Augment water supplies where necessary.
3. Take over major headworks systems and operate them to maintain a secure supply of water for irrigation districts and other users supplied by those works.
4. Support the rehabilitation and expansion of water supply systems within irrigation districts to ensure efficient distribution of water.
5. Transfer water from one sub-basin to another within the South Saskatchewan River Basin where it is publicly desirable to do so.
6. Manage watersheds in forest reserves to maintain water supplies for instream and downstream uses.
7. Provide practical and equitable sharing of the costs associated with making water available for use in cases where public benefits can be realized.

Water use

1. Allocate water for beneficial purposes as long as the adverse effects on the present and future use and management of water are minimized.
2. Encourage water users to minimize waste, and use water more efficiently.
3. To make the most economical use of existing works and the water supplied through these works, preference in allocating water for new irrigation development is given to lands that can be served by the works of existing irrigation districts.
4. Improvements in the efficiency of irrigation water use through rehabilitation of storage and distribution systems take priority over increasing the amount of irrigated land.
5. Allow the use of rivers for water power where it does not interfere with the maximum advantageous use of the power and other resources of the rivers.
6. Where appropriate, reserve unallocated water until the best use of that water can be determined.
7. In reserving surface water for future development in the South Saskatchewan River Basin, the first priority is given to designating water for irrigation.
8. Guarantee the existing water rights of irrigation districts.
9. Domestic use has first priority for the allocation of groundwater.

Water quality

1. Control pollution at its source.
2. Use the assimilative capacity of rivers to purify or absorb wastes.
3. Prohibit pollution that endangers water uses or causes the overall aquatic environment of an area to deteriorate.
4. Guarantee the quality of water for domestic use.
5. Impose effluent standards high enough to avoid frequent revision of the standards as the use of assimilative capacity increases.
6. Apply effluent standards at least as stringent as those set nationally in Canada.
7. Require municipal sewage treatment to remove 85% to 95% of oxygen demanding waste and 85% to 95% of suspended solids. Where this level of treatment does not provide sufficient protection to the water environment, additional treatment may be required.
8. Industries, generally, are required to use the best practicable technology for control of waste loadings to water bodies. Industries may be required to employ the best available technology where the risks to the environment warrant it.
9. Ensure that hazardous industrial wastes are managed to obtain maximum protection of the environment and public health.
10. Watersheds in forest reserves are managed to protect water quality for fish habitat, recreation and downstream water users.
11. Industrial polluters, generally, must pay the costs of cleaning up their pollution and the direct costs arising from that pollution. Public subsidies are not provided to industries for pollution control.
12. Share with local authorities the costs of municipal water treatment and sewage disposal facilities.

6

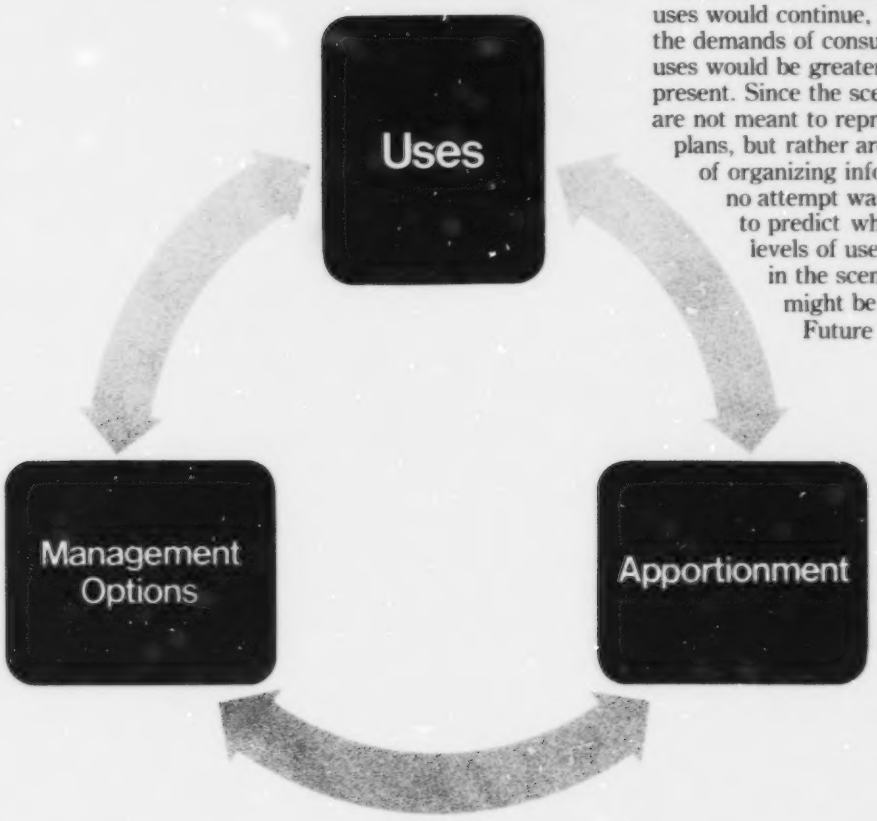
Scenario Development & Analysis

Information relevant to the strategic policy questions raised in the introductory chapter was synthesized in the form of a number of scenarios of future water use and management. These scenarios were analyzed to determine the water supply/demand balance and the water quality conditions that might be expected under different management options. The scenarios were then evaluated in relation to the province's economic and social objectives. The purpose in presenting these scenarios is not to suggest that any one of them should be selected as the preferred strategy, although this could be a result. Rather, the purpose is to provide some understanding of the range of possibilities that could be incorporated in a strategy, to serve as a basis for making policy decisions that will be the foundation of a future water management strategy. These strategic policy decisions relate to:

- the allocation of water among uses,
- priority among management options,
- the contribution of each major river – Red Deer, Bow, Oldman – to the apportionment requirement of the South Saskatchewan River system.

Future Water Use

Each scenario was designed to illustrate a water use condition that could be realized in the forseeable future. As discussed in earlier chapters, there are seven principal uses of the water in the South Saskatchewan River system: domestic/municipal, industrial, irrigation, hydroelectric generation, fish habitat, recreation and waste disposal. In setting up the scenarios it was assumed that these same uses would continue, but that the demands of consumptive uses would be greater than at present. Since the scenarios are not meant to represent plans, but rather are ways of organizing information, no attempt was made to predict when the levels of use included in the scenarios might be realized. Future



levels of water use will be dictated primarily by decisions or events independent from water management that cannot be predicted with any degree of reliability, such as market conditions for agricultural and manufactured goods or economic development patterns that shape the growth of urban centres. A workable water management strategy must be developed with a view to accommodating the kinds of uses that are foreseeable.

The following paragraphs outline the basis of the future water use shown in the scenarios. (Readers who are interested in more detailed information about the water demands or effluent loadings of particular uses should refer to the SSRBPP Scenario Report.)

The future municipal water requirements and sewage effluent loadings that are built into the scenarios are based on projections provided by the four urban centres (Red Deer, Calgary, Lethbridge and Medicine Hat) for the year 2000. These four centres currently account for over 90% of municipal water use and for an even greater percentage of municipal sewage effluent discharges into the major rivers. It is likely that in future years, these uses will continue in the same proportions. These projections were made in the boom years of the early 1980's. Although in light of recent economic conditions they may be somewhat optimistic for the year 2000, they are probably reasonable forecasts for the foreseeable future.

The future industrial water requirements and effluent loadings are based on the informed opinions of government agencies and research establishments involved with industrial and economic development. The water requirements reflect a level of planned or proposed industrial development, principally in energy-related industries such as petrochemicals and thermal-electric generation, that is likely to be realized in the foreseeable future if economic conditions are favourable.

This same level of municipal and industrial water use and effluent discharge was assumed for all scenarios. Since municipal consumption accounts for only 3% and industrial only 1% of the total water consumption in the basin, the analysis would be sensitive only to a substantial increase in the assumed municipal or industrial use.

Future irrigation water requirements are based on the number of acres assumed to be irrigated, which varies from one scenario to another. The per unit (acre) water requirement for irrigation that was used in structuring the scenarios reflects conventional irrigation practice in the basin, and varies from year to year depending on weather conditions. The total irrigation water requirement varies between sub-scenarios, depending on the number of acres irrigated.

Water requirements for the maintenance of suitable fish habitat were developed in consultation with the Fish and Wildlife Division of Alberta Energy and Natural Resources. The desirable streamflow and reservoir levels for recreational use were established by a panel of advisors from a number of government agencies with an interest in recreation. The pattern of storage and release of water from the reservoirs in TransAlta's Bow River hydro system that would be most preferable for generating electricity was provided by TransAlta Utilities.

The water requirements for maintaining preferred fish populations or recreational opportunities do not change regardless of changes in numbers of fishermen, recreationists or tourists using the water for these purposes. There are no known intentions for modification of TransAlta's hydro generating capability that would necessitate any long-term change in the pattern of storage and release of water from the hydro reservoirs on the Bow River system. Consequently, the water requirements for the non-consumptive uses – fish, recreation, hydro – are constant in all scenarios.

Scenario Structure

The scenarios presented in this report were structured to satisfy several requirements consistent with their role of providing an information base for informed debate on policy questions. Briefly, the scenarios must:

- reflect the full range of water uses in the basin;
- illustrate a significantly wide, but realistic range in levels of use;
- be related to the economic and social objectives of the province, and
- demonstrate the effects of different policy options and combinations of options.

Since an infinite number of scenarios is possible with different levels and priorities of use and combinations of policy options, an overriding requirement was to keep the number of scenarios to the minimum that would adequately illustrate the range of choices.

Four basic scenarios, subdivided into 17 sub-scenarios, are presented in Chapter 7 of this report. Scenario 1, which includes the Base Case subscenario, was structured to reflect the expected level of consumptive water use when municipal and industrial growth reach their forecast level, and when the irrigated acreage has increased to keep pace with the implementation of the water resources and irrigation development decisions announced by the provincial

government in 1980, about 350,000 acres more than was irrigated in 1982. The management measures noted in those decisions, some of which are being implemented now, include:

- a reservoir to provide about 400,000 acre-feet of storage on the Oldman River;
- rehabilitation and modernization of the Waterton-St. Mary headworks system;
- rehabilitation and enlargement of the St. Mary Irrigation District main canal, including a 70,000 acre-foot reservoir at the Forty-Mile Coulee site;
- enlargement of the LNID headworks, including enlargement of Keho Lake;
- rehabilitation and enlargement of the Carseland-Bow headworks system;
- rehabilitation and enlargement of the WID headworks canal;
- rehabilitation and enlargement of the Eastern Irrigation District headworks canal;
- rehabilitation of the Mountain View-Aetna headworks system;
- renabilitation of the United Irrigation District headworks;
- rehabilitation of the Ross Creek Irrigation District headworks;
- Badger Lake offstream reservoir in the Bow river Irrigation District;
- Crawling Valley offstream reservoir in the Eastern Irrigation District;
- Sheerness Pipeline and Deadfish Diversion projects in the Red Deer sub-basin.

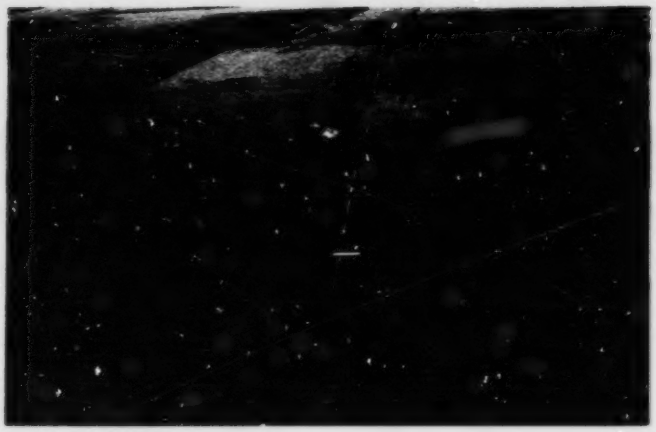
Scenario 1 also illustrates the effect of varying the priority of water use among fish, recreation and irrigation, and illustrates some of the consequences of land disposal of Calgary's and Lethbridge's sewage effluent.

All four scenarios have been structured to illustrate patterns and levels of irrigation expansion that could be sustained with different water management strategies.

Scenarios 2, 3 and 4 are structured to illustrate possible levels and distribution of irrigation expansion beyond that illustrated in the Base Case. Three different patterns of irrigation expansion are portrayed:

- expansion in areas that can be served by the works of existing irrigation districts;
- expansion into areas not served by existing districts, but where there is a perceived demand for irrigation (Little Bow River basin and the Special Areas in the eastern extremities of the basin);
- the maximum expansion possible with the water supply in the South Saskatchewan River system.

This structuring has been based on certain important facts about irrigation and its role in southern Alberta.



There are about eight million acres of land in the South Saskatchewan River Basin with soils that are suitable for irrigation. Of this amount, slightly more than one million acres are currently irrigated, mostly in areas served by irrigation districts with water from the Bow and Oldman river systems. The levels of irrigation illustrated in the scenarios range upward to over two million acres, the maximum that could be irrigated under conventional irrigation practices with the water supply that could be made available from the South Saskatchewan River system.

There are many factors other than the suitability of the soil and the potential water supply that will determine how much land will be irrigated in the basin in future years. These include market conditions for agricultural products, the state of the economy in general and of the agricultural industry in particular, and the availability of money to finance the infrastructure necessary to get the water onto the land. None of these are predictable. There are, however, a number of factors that indicate the importance of irrigation and potential irrigation expansion to the development of a water management strategy for the basin:

- irrigation is by far the predominant user and consumer of water in the basin;
- irrigation is the only consumptive use of water that has the potential for growth in sufficient proportions to make an appreciable difference in the water supply/demand balance in the basin;
- the settlement patterns and commercial activity that are in one way or

another attributable to the practice of irrigation are a major element of the socio-economic fabric of rural southern Alberta, and

- irrigation in Western Canada has been, since its beginning, and will likely continue to be, an instrument for developing or stabilizing regional economies.

Some preliminary analysis was done to establish and rationalize the means used to limit the number of scenarios developed for final analysis and presentation. These were:

1. Fixed water requirements were established for each use except irrigation and waste disposal, and held constant through all scenarios.

As noted in the discussion of future water use, municipal and industrial water use was set at levels likely to be realized in the foreseeable future. Compared to irrigation water use or the water supply in the basin, municipal and industrial water use is such that the water supply/demand analysis is relatively insensitive to any realistic increase or decrease in these uses. The streamflows or reservoir levels required to provide acceptable conditions for fish habitat or recreation are absolute; they do not change in relation to the number of anglers or recreationists using the water.

2. Variations in the priority of water use were examined only in Scenario 1.

The water requirements for municipal, industrial and hydro use were jointly given first priority in all scenarios. As noted above, municipal and industrial uses consume very little water, consequently, they are not in conflict with hydro use. As will be discussed, the use of hydro storage for irrigation use was assessed as a storage management option rather than as a priority option. Fish habitat or recreational use were given priority over irrigation in three sub-scenarios.

Maintaining streamflows or reservoirs at the most desirable levels for these uses has serious consequences for irrigation at the Base Case level, and would preclude any further expansion of irrigation. The streamflow required for effective waste assimilation would be equal to or greater than that required for fish habitat and would have similar consequences for irrigation expansion.

3. Of the innumerable combinations possible, the scenarios illustrate four different ways in which the flows of the major rivers might be managed to contribute to interprovincial apportionment requirements.

- No fixed allocation (shown in Scenario 1 only);
- an allocation approximating the current condition: 75% of the Red Deer and 40% of each of the Bow and Oldman rivers;
- an equal allocation: 50% of the flow of each major river;
- a lesser contribution from the rivers most heavily used for irrigation: 90% of the Red Deer and 30% of each of the Bow and Oldman rivers.

The apportionment contribution requirements are constraining only in critical years, years when flows are low and consumptive demands are high. On average, each river would pass a greater percentage of its flow than required for apportionment, and Alberta would pass more than the 50% of natural flow required to Saskatchewan.

4. In all but Scenario 1, the management options are limited to storage for achieving a supply/demand balance and to advanced sewage treatment for the maintenance of water quality.

There are four purposes for which water management is required in the scenarios: to meet fish habitat, recreation, irrigation or water quality requirements. Management for fish habitat and recreation is illustrated in three sub-scenarios, where the required streamflow and reservoir levels are met through operation of storage reservoirs at the expense of irrigation.

There are three basic ways in which the water supply and demand for irrigation can be balanced: by increasing the supply available for use, by using the available supply more efficiently, or by reducing the demand. Only the first of these, increasing the available supply through reservoir storage, is evaluated as a management option in this analysis.

Reducing irrigation water demand is not treated as a management variable in the scenarios. Under conventional irrigation practice, the number of acres irrigated in a scenario could increase if irrigators accepted the greater economic risk associated with greater or more frequent water deficits, or could decrease if they demanded more security than is assumed in this analysis. The level of risk assumed is built into the economic performance criteria outlined later in this chapter under Analysis and Evaluation. It guarantees economic success with periodic water supply deficits of up to 25%. The level of performance illustrated in the scenarios is very much influenced by the occurrence of successive high demand/low supply years in the period of analysis.

The demand for irrigation water could change if farmers, for whatever reason,

chose to apply more or less water to the land. If, as is generally believed, the conventional practice is to apply less water to the land than is required for maximum production or optimal economic return, it seems unlikely that the demand would be reduced at the farm level. If farmers chose to apply more water to the land, the number of acres irrigated in each scenario would be reduced, unless it was possible to provide the additional water required at the farm through more efficient (less wasteful) use of the water diverted for irrigation.

One method of reducing the demand for water at the farm or for encouraging more efficient use of water would be to charge the user for water on a per unit basis. However, not enough is known about the price elasticity of the demand for water for irrigation to present a meaningful evaluation of this option. One effect could be to reduce the number of acres irrigated. Alternatively, per unit pricing of water might be an incentive for more efficient use and management of water.

Improving the efficiency of irrigation water use is not included as a management option in the scenarios. There is not enough reliable information available about the current state of irrigation water use efficiency in the basin, nor about opportunities to improve on that efficiency, nor on the type, the scale and, therefore, the cost of the measures that would achieve improvements, to allow a meaningful evaluation of this option. Improvements in efficiency would permit either the irrigation of more acres of land or the application of more water per acre, with no change in the supply of water to irrigation districts. Alternatively, they would permit the irrigation of the same acreage illustrated in the scenarios, but with a reduction in the supply of water to irrigation districts, and consequently, a reduction in the amount of reservoir storage required to maintain the supply. The relationship between irrigation water use efficiency and reservoir storage capacity requirements is addressed in more detail in the SSRBPP Scenario Report.

The reservoir storage options that are illustrated in the scenarios range from no storage beyond that included in the Base Case scenario to the maximum storage capacity that would be effective with the natural water supply in the basin. Specific sites for reservoir storage were not determined.

There are three ways of effectively managing water quality in the South Saskatchewan River Basin: by maintaining streamflows adequate for the assimilation of wastes, by imposing higher effluent standards and thus necessitating advanced treatment of effluents, or by disposing of effluents on the land rather than in the water. As is illustrated in Sub-scenario 1B, the high streamflow required to maintain fish habitat does not provide water quality adequate for all uses and precludes irrigation expansion. Consequently, maintenance of the even greater streamflow that would be required for adequate waste assimilation was not evaluated as a management option.

Sub-scenario 1E illustrates the effect on water quality in the Bow and Oldman rivers of land disposal of Calgary's and Lethbridge's sewage effluent. Because the effect would be similar in all cases, the management option was not evaluated for other urban centres or in other scenarios.

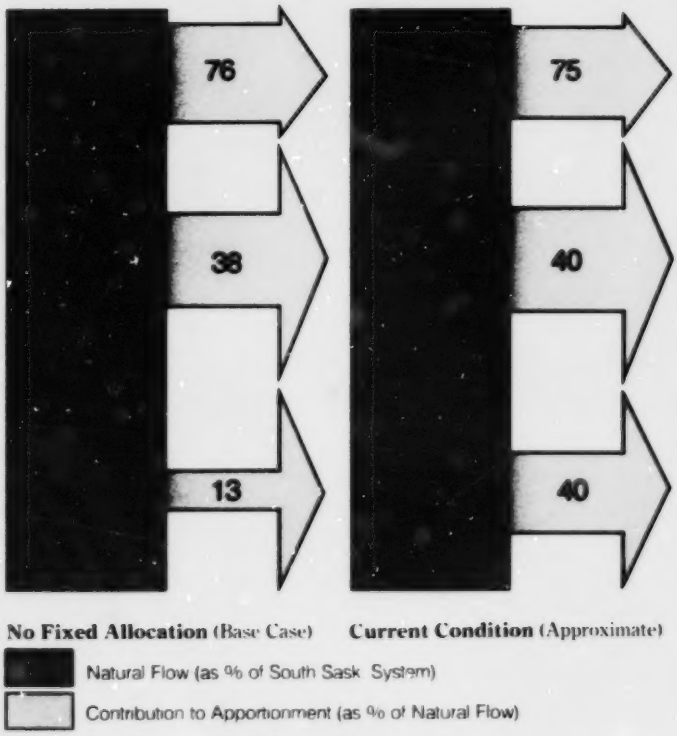
Advanced treatment of the sewage effluent of the four urban centres is evaluated as a management option in all scenarios.

Interrelationship of Policy and Management Variables

The scenarios illustrate the effects of varying some of the options in the three policy areas: use priority, sub-basin apportionment allocation, and water management measures. In considering the scenarios and the policy decisions to be made, it is important to recognize the interdependence of these variables.

Use and Sub-basin Apportionment Allocation

The priority of use, whether a non-consumptive instream use (fish or recreation) or a consumptive



withdrawal use (irrigation), affects the amount and timing of the water supply flowing through a given river system in a given year. Water allocated to instream use flows through the system and contributes to the inter-provincial apportionment flow requirement. If the instream flow requirement is high, more water may be passed on than is necessary for apportionment. Conversely, if the allocation of the flow in a river for apportionment is substantial, instream flow requirements may well be met even if they are of lesser priority than withdrawal uses. However, this is not necessarily the case. Since inter-provincial apportionment is calculated as a percentage of the total annual flow, the apportionment requirement could be met from flows that cross the boundary during the peak flow period (mid-May to mid-July) and during the winter, when consumptive withdrawal uses are minimal. In such cases, streamflow from mid-summer to early fall, when irrigation withdrawals are still substantial, could be less than required for instream uses. Similarly, the percentage of streamflow that is allocated for apportionment places limits on consumptive uses, such as irrigation.

In the scenarios, the inter-provincial apportionment flow requirements are always satisfied; on an annual flow volume basis, apportionment has priority over all other uses.

Sub-basin Apportionment Allocation and Storage

The percentage of river flow that a sub-basin must contribute to inter-provincial apportionment dictates the amount of reservoir storage that is required to sustain a given level of withdrawal use in that sub-basin. The greater the percentage of flow allocated to apportionment, the greater the storage capacity required.

The minimum apportionment allocation for a sub-basin is established for the most critical years – those years when the natural flow is at its lowest and the demands of consumptive uses are at their highest. Similarly the reservoir storage capacity is calculated to satisfy the requirements of the consumptive uses during critical years. In most years, then, contributions to inter-provincial apportionment will be greater than necessary, and carry-over storage will not be required.

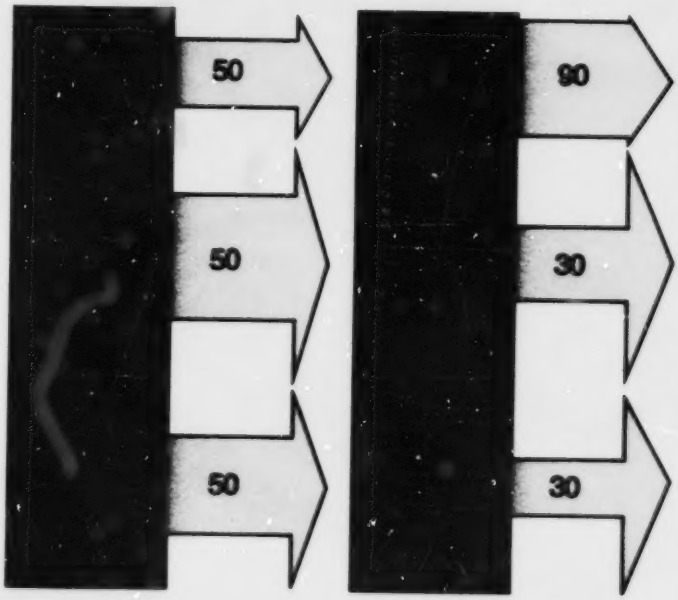
Reservoir Storage and Use Priority

The storage capacity required in a sub-basin depends on the demands of the uses that must be satisfied with the natural water supply. The satisfaction of all uses would require a certain amount of storage capacity, which would not change regardless of priority among uses. The scenarios in this report were structured to illustrate the requirements and effects of satisfying one use at the expense of others. Consequently, the storage capacities illustrated are those required to satisfy irrigation requirements only.

Reservoir Storage and Water Use Efficiency

For reasons discussed in the preceding section, improvements in water use efficiency are not illustrated as management options in the scenarios. While there may be opportunities for improving efficiency in municipal and industrial use, it is apparent from a consideration of the water requirements of the different uses that, from a basin supply/demand balance perspective, the most appre-

The apportionment contribution requirements are constraining only in critical years, when flows are low and consumptive demands are high.



Equal Allocation

High Allocation — Red Deer
Low Allocation — Bow and Oldman

Fig. 6.1 Management Options for Apportionment

ciable gains would be realized through improvements in irrigation water use efficiency. Consequently, the relationships between irrigation water use efficiency, reservoir storage requirements and irrigated acreage should be kept in mind when reviewing the scenarios. In any scenario, a percentage improvement in irrigation water use efficiency would allow either a reduction in the storage capacity, and thus greater instream flows, or an increase in the number of acres irrigated in that scenario.

Analysis and Evaluation

For each sub-scenario, the water balance conditions were analyzed with the use of a computer model that simulates the monthly water supply (streamflow and reservoir levels) and demand conditions over the period of analysis. Similarly, water quality conditions were analyzed for each sub-scenario with the use of a water quality computer model that predicts the water quality conditions that could be expected under the streamflow conditions simulated in the water balance analysis.

The water quality and water balance conditions in each sub-scenario were evaluated in terms of:

- performance criteria for irrigation, fish habitat, and recreational, municipal and industrial water uses;
- net value added and job creation attributable to irrigation, and
- the cost of water management measures.

Performance Criteria

The performance criteria established for different water uses and applied in the evaluation are summarized below. The performance criteria used to evaluate water quality define conditions that would have major or minor impacts. The parameters used to assess impact vary from use to use, however, the definitions of a major impact as one that imposes a limitation on a use, and of a minor impact as one that has a harmful, though not limiting, effect on a use are used consistently throughout the evaluation.

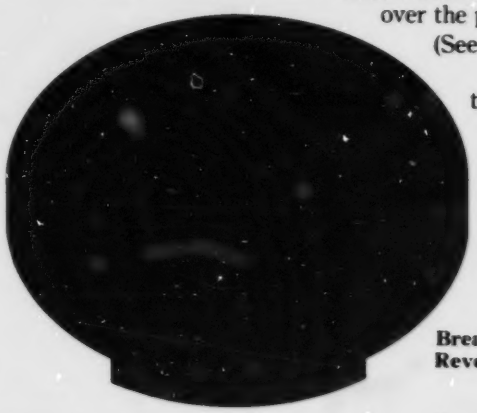
Irrigation

Two economic performance criteria were used to measure whether irrigators could sustain a water shortage and still maintain economically viable farming operations. The first of these was the **minimum return criterion** – the level at which an irrigator's revenue is sufficient to pay his operating costs and debt payments. The second is the **break-even criterion,** the level at which an irrigator's revenue is sufficient to pay all his annual expenses, including operating costs, debt repayment, labour costs and depreciation. Each criterion was designed to protect an irrigator with a debt-to-assets ratio of 0.5 or less. Establishing the criteria at this level protects both established irrigators, 90% of whom have a debt-to-assets ratio of less than 0.5, and those who are just beginning in irrigation. The average debt-to-assets ratio for Alberta irrigators is 0.1. A failure was considered to have occurred if the gross revenue for an irrigation district fell below the **minimum return** in any year, or below the **break-even return** on average over the period of analysis. (See Fig. 6.2)

In this analysis, the returns to irrigation projects located entirely within Agroclimatic Zone C (the Western Irrigation District, private irrigation along the Red Deer River and on the Peigan and Blackfoot Indian Reserves) do not satisfy the break-even criterion. This is because conventional irrigation practice under the agroclimatic conditions in this zone does not produce crop yields sufficient to provide the revenue necessary to meet the criterion. The amount by which these projects fail to meet the break-even criterion is small (3% to 4%), and is not considered to be an economic failure in the scenario evaluation, since irrigation as it is presently practiced in this zone is economically viable, although the irrigators may be receiving a lesser return on their investment than irrigators in other zones.

The economic performance of irrigation was not evaluated for the United, Mountain View, Aetna and Leavitt irrigation districts. Not enough information about water use and irrigation practices in these districts is available to utilize the performance criteria in a meaningful way. Similarly, net value added and job creation, as discussed later in this chapter, were not estimated for these districts.

In the scenario evaluation, the **average maximum water supply deficit,** expressed as the percentage by which the water supply is less than the water demand, is used as a general indicator of the irrigation water supply/demand balance condition. It



*At a 0.5 debt-to-assets ratio.

Fig. 6.2
Performance Criteria for Irrigation
(Based on Farm Revenue)

is the average of the maximum one year water supply deficits that occur in each irrigated area over the period of analysis. This value also serves as a crude index of the economic performance of irrigation in the basin. In general, the greater the average maximum water supply deficit, the poorer the economic performance.

The occurrence of salinity (salts), bacteria and viruses, and eutrophication create water quality conditions that can affect irrigation in the basin. Criteria were established to define both major and minor impacts from salts. Only minor impact criteria were established for bacteria and viruses and for eutrophication. Bacteria and viruses affect only certain specialty crops, and only during a brief period prior to harvesting. Heavy weed and algae growths, which restrict the flow of water in canals and clog irrigation equipment, are a nuisance and an expensive one, but are not a limiting condition for irrigation.

Fish Habitat

Streamflow requirements for fish were established in relation to the flows necessary to maintain habitat suitable for the different life stages of the various species of fish. A five-point scale was established for each river that defined flow conditions that resulted in impacts on fish habitat ranging from a major

negative impact through moderate negative impact, no impact (acceptable habitat) and moderate positive to major positive impact.

The water quality characteristics that most often limit fish production and distribution in the South Saskatchewan River system are the water temperature and the concentrations of dissolved oxygen and unionized ammonia. The other water quality related characteristic that has an impact on fish habitat is the trophic condition of the river. Criteria were established for these parameters of water quality that defined conditions that would have no impact, a minor impact or a major impact on fish habitat.

Recreation

Criteria were established for judging the impact of streamflow and reservoir level conditions on a range of representative recreational uses. Streamflow criteria were established for boating, based on the minimum flow requirements for canoeing, and for angling, based on the performance criteria for fish habitat. Criteria for reservoir levels were based on minimum surface water elevations at which physical conditions such as navigational hazards, steep slopes, or mud flats would make recreation extremely difficult or impossible.

The performance criteria were set to define major, moderate and minor levels of negative impact. The level of impact was defined in terms of the number of months over the period of analysis that the minimum streamflow or surface water elevations were not met.

The water quality criteria that defined major and minor impacts on recreation were set for the two parameters that pose major problems for recreational use: coliform levels (for bacteria and viruses) and trophic conditions (for algae and weed growth).

Municipal

Municipal water requirements were always satisfied in the scenarios, so no performance criteria were necessary for quantity of water. Public water supply criteria were applied for water quality. Heavy metals and organic residues are not a problem in the South Saskatchewan system and no significant increase in point source loadings of these materials is foreseen. The criteria that were applied were based on values for total coliforms, total dissolved solids, nitrates and sulphates.

Industrial

Industrial water requirements were always met in the scenarios so no criteria for water quantity were necessary.

There are three basic industrial uses of water: cooling, power generation and processing. Quality requirements for cooling and boiler water are fairly standard among industries, whereas the requirements for process water, which comes in contact with the product, are specific to particular industries. Industrial water criteria, generally, are less restrictive than those for other uses, such as fish habitat or municipal water supply, and exceeding the

industrial criteria is unlikely, even under extreme conditions. The criteria applied were based on values for total dissolved solids, temperature, alkalinity, ammonia, magnesium, nitrate, phosphate, sodium and sulphate. Existing water treatment technology, although costly, usually permits industrial use of most water. Since none of the criteria are absolutely limiting for industrial use, all impacts were classified as minor.

Net Value Added and Job Creation

Net value added is a measure of economic productivity. In this analysis, it is the amount of money added to the provincial economy by irrigated agriculture and by industries that process the products of or provide goods and services to irrigated agriculture. The net value added and the number of jobs illustrated in each sub-scenario represent the net increase, attributable to irrigation, over the net value added and jobs that would be realized if the same land was used for dryland farming.

Although the costs to irrigation farmers and industries were accounted for, the calculation of net value added did not consider the costs of diverting, storing or delivering water to the farmer. As a result, to get a true picture of the economic impact of irrigation, net value added must be compared to the costs for storage, headworks and district works.

Rehabilitation of irrigation works

The number of jobs created by irrigation was calculated from net value added, since in every industry, a certain amount of net value added is required to support each job. Included in the number of jobs are farmers engaged in irrigation farming, over and above the number of farmers that could be supported by dryland farming.

It should be noted that while recreational water uses (including tourism and angling) add to the net value of the economy and have job creation potential, there is insufficient reliable data on the relationship between water conditions and the number of people using water for these purposes to support an evaluation similar to that for irrigation use.

Costs of Water Management Measures

The information on costs is comprised of estimates of the expenditures that would be required to support irrigation development and to improve water quality. The irrigation costs are for the additional reservoir storage and the rehabilitation and enlargement of headworks and district works that would be required to support the level of irrigation development indicated in each sub-scenario. On-farm irrigation costs are included in the calculation of net value added. The cost of rehabilitating and enlarging district works to support the planned level of irrigation development, illustrated in the Base Case, is estimated at $927 million. Indications are that this work will proceed at an annual rate of expenditure of $40 million.

The costs for water quality improvement include estimates of the expenditure that would be required for secondary and advanced treatment of the future sewage discharges of the four urban centres, and in one sub-scenario the cost of a conceptual scheme for irrigating land with Calgary's sewage effluent.

The basis for developing cost estimates of water management measures is discussed later in this chapter.

Drainage of Irrigated Lands

To provide estimates of the water quality of irrigation return flows, it was assumed that tile drainage would be installed in 13% to 37% of the land in existing irrigation districts and 10% to 20% of the land in "new" districts.

Readers who wish more information on the evaluation methodologies and performance criteria are referred to the SSRBPP Scenario Report, or the technical reports prepared for the SSRBPP that are specific to the subject.

Regional Perspective

For the purpose of evaluating the scenarios, the economic benefits of irrigation were aggregated in two ways:

- relative to the sub-basin in which the irrigated land is located;
- relative to the river basin that is the source of water used to irrigate the land.

Only the latter is presented in this report. Data reflecting both aggregations are presented in the Scenario Report.

This was done to illustrate a difference in perspective; however, neither of these aggregations is satisfactory from the viewpoint of an economic or social analyst. A river basin is a physical region, a watershed, which

P.F.R.A. Photo

St. Mary Dam and Reservoir

encompasses the land area drained by a river. As such, it is ideally suited for the determination of water supply, or for considering localized natural phenomena such as erosion or flooding. Only rarely, however, is a river basin coincidental with an economic or cultural or political region.

Water is publicly owned, a mobile resource and a free good, characteristics shared with no other natural resource except air. These characteristics make it more difficult to objectively evaluate the use and management of water than of other resources.

As noted in Chapter 2, the irrigation of land located in one sub-basin with water diverted from another sub-basin, intra-basin transfer of water, has been practiced in the basin since the early part of this century. Consequently, water management measures implemented in one sub-basin may result in benefits accruing to or derived from the use of that water for irrigation in another sub-basin, which may or may not be within the same economic or cultural region. Similar situations are possible within a sub-basin. A reservoir constructed in an economic or cultural region in the headwaters of a sub-basin may be perceived as a disadvantage in that region, but the use of the water provided by the storage reservoir for irrigation downstream produces benefits in another economic or cultural region. Conversely, the benefit derived in an upstream region from the disposal of waste in a river may produce great disadvantage in another region downstream. When either case is viewed from a broader perspective – the basin as a whole, or the province – the benefits may be considered to outweigh the disbenefits, or vice versa.

It has not been possible to illustrate the regional considerations, but they should be kept in mind when reviewing the scenarios.

Design Period for Analysis

The natural water supply conditions depicted in the scenarios are based on streamflow conditions recorded at different locations in the basin during the years from 1912 to the present. It is conventional to use historic streamflow records for water management planning, which assumes that the hydrologic record for the preceding 70 or so years provides a reasonable indication of the kind of streamflow conditions that can be expected in the future. The water supply and demand conditions that were analyzed for the scenarios were those experienced during the 28-year period from 1928 to 1955. This period includes the longest periods of prolonged low flow – 1929 to 1941, and of high flow – 1951 to 1955, in the 70-year period on record. It also includes the most critical supply/demand years, 1934 to 1941. The storage capacities and the economic performance of irrigation illustrated in the scenarios are very much influenced by conditions during these years. It is, of course, possible that hydrologic conditions more severe than those experienced over the past 70 years could occur in the future. For example, the "greenhouse effect" that is currently attracting the attention of researchers interested in global climatic phenomena, could cause a significant reduction in natural water supplies and a considerably greater demand for water in the South Saskatchewan River Basin. However, the implications of such an eventuality are not well enough understood to be addressed in this analysis, and accompanying changes of similar or greater magnitude on a global scale, such as

population distribution or patterns of food production and consumption would render this analysis of little consequence.

Since river water quality conditions in one year are not affected by those in a preceding year, the water quality analysis was based on two types of flow conditions rather than on the continuous 28-year record. The flow conditions analyzed were those experienced in an average year, and those experienced in a low-flow year.

Costs

Conceptual costs are presented for the management alternatives identified in the scenarios. General costs were developed using data from a number of previous site-specific studies of water management projects. The cost data were brought to 1983 dollars, and included engineering, direct land damages and contingencies. These cost estimates account for some regional differences but could be expected to vary considerably if site-specific studies were undertaken.

The projects that were costed include reservoirs, irrigation headworks and district works, land disposal of sewage effluent, secondary and advanced sewage treatment, and utilization of TransAlta hydro reservoirs.

Reservoirs

Costs for onstream reservoirs were developed as a function of live storage capacity and spillway design discharge. It was found that the spillway was a very significant factor in the cost estimate of most onstream reservoirs. Consequently, similarly-sized reservoirs on the Bow, Oldman or Red Deer would have different costs.

In general these costs showed considerable economies of scale. For a similar-sized spillway the costs show that doubling the live storage from 400,000 to 800,000 acre feet would change the cost from $325 to $390 million.

The cost of offstream reservoirs was related to live storage capacity and average reservoir depth. The relationship indicated that for reservoirs of similar capacity, doubling the average depth would more than double the cost.

Irrigation Headworks and District Works

Capital cost estimates were developed for the new irrigation areas that are shown in the scenarios. These costs include the main supply diversion structure, main canal to the irrigation area and the distribution system within the area irrigated. It was assumed that water for these areas would be supplied by gravity diversion from a major water course (Bow, Oldman, Red Deer, or South Saskatchewan rivers).

The size of the main canals from the diversion weir to the irrigated area were determined by the expected peak flow requirements, and were costed on the basis of the relationship between cost and capacity.

For the distribution system, general costs were developed that related the cost per acre to the total area irrigated. These costs were based on what were considered to be typical combinations of lined and unlined canals and pipeline systems for a standard layout.

Estimates of the costs of rehabilitation and expansion in existing irrigation districts were provided by Alberta Agriculture.

Secondary Sewage Treatment

The estimated costs of secondary sewage treatment for the four urban centres were provided by Standards and Approvals Division, Alberta Environment.

Advanced Sewage Treatment

Advanced treatment of sewage effluent at Red Deer, Calgary, Lethbridge, and Medicine Hat is introduced as a management measure in the scenarios. The level of treatment is that required for virtual elimination of bacteria and viruses, reduction of phosphorus concentrations to 0.2 mg/l and reduction of ammonia concentrations to 2.0 mg/l. The cost estimates are based on chlorination and dechlorination for bacteria and viruses, an alum precipitation process for phosphorus removal, and biological nitrification for ammonia reduction.

Land Disposal of Sewage Effluent

Capital costs were estimated for three effluent irrigation schemes and two rapid infiltration schemes utilizing the year 2000 estimates of the City of Calgary's sewage effluent. Only one effluent irrigation scheme using 100% of Calgary's effluent is illustrated in this report. Data on the other schemes are presented in the Scenario Report.

For the effluent irrigation schemes, the capital costs included a pump and pipe conveyance system to a reservoir, land purchase and easement costs for a reservoir and conveyance system, and a pressure pipe distribution system below the reservoir to the fields to be irrigated. The costs identified include everything except on-farm costs, which, as with conventional irrigation, are included in the calculation of net value added from effluent irrigation. Operation and maintenance costs were estimated to be 1.5% of the capital cost.

For the rapid infiltration schemes, the costs included a pump-and-pipe conveyance system to the site, land and easement purchase for infiltration basins and for the pipeline, construction costs for the infiltration basins, and the distribution system costs within the infiltration basins. Operation and maintenance costs for the rapid infiltration schemes were estimated as 3.8% of capital cost using the annual effluent, and 2.3% of

Table 6.1 Hydro Reservoir Utilization

Volume of Annual Storage Utilized (acre feet)	Frequency of Use	Present Value Cost (millions of dollars)
425,250	100%*	395
348,300	100%*	285
348,300	50%**	185
348,300	25%***	132

* *used every year*
** *used every 2nd year*
*** *used every 4th year*

capital cost using the winter effluent only.

Utilization of TransAlta Hydro Reservoirs

The hydro reservoirs on the Bow River, which are owned by TransAlta Utilities, are operated to provide power for the Alberta Interconnected System. These reservoirs fill over the summer in an operation that stores part of the runoff and passes most of the remainder through the various plants to generate electricity. The stored water is released during the winter period to generate power for both peak and base load requirements. An option for augmenting the summer water supply on the Bow River is to obtain releases from the TransAlta reservoirs to meet the downstream demand. Such releases would alter TransAlta's current preferred operating mode and would result in a cost to the utility. The total live storage capacity of the TransAlta hydro reservoirs is 650,000 acre feet.

A study was done to assess the approximate costs of replacing the hydroelectric generation that would be lost if the Bow River hydro reservoir operations were changed. The assessment considered the effect of any overall loss of energy that might impair system reliability, the need for replacing lost generating capacity through new expansion or purchase of power from neighbouring utilities, and the general loss of operating flexibility. The expected requirement for generating capacity expansion was also considered. The estimated cost accounts for capital, operating and fuel costs for using replacement capacity. The assessment was based on a 45-year period.

If the hydro reservoirs were used to their fullest extent every year of a 45-year period to augment supply, the present worth cost would be about $395 million. This cost represents an upper limit for using the Bow River hydro system for irrigation water supply. The cost analysis is sensitive both to how much summer storage is used and how often it is used. A range of costs, based on the varying amounts and frequency of water use is presented in Table 6.1. The costs decrease as the frequency of use is reduced, however, the lower limit of the costs would be the capital cost of the replacement capacity required to maintain system reliability.

These costs are considered to be preliminary estimates that, in the event of negotiation to change the reservoir operations, would have to be determined according to the specific conditions imposed by the uniqueness of the change proposed. The cost estimates will also be sensitive to the expected future fuel costs and the expected rate and amount of general capacity expansion in the AIS to meet expected increased demands for electric power in the future.

The use of TransAlta's storage to meet downstream demands is a potential alternative to the development of additional onstream storage. Depending on the volume of water required and the frequency of summer use, the cost of replacement generation might prove less costly than developing new storage.

7

Scenarios

This chapter is a brief summary and explanation of the description, analysis and evaluation of the scenarios. The more pertinent information for each sub-scenario is illustrated on the panels accompanying this report in a form that facilitates comparison of the structure and evaluation of the sub-scenarios. Readers who wish to have more detailed information on the analysis and evaluation of scenarios are referred to the SSRBPP Scenario Report.

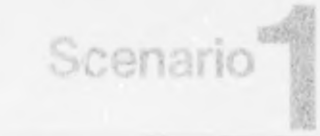
Some of the characteristics of the scenarios as described in the previous chapter bear repeating here:

1. As a general rule, the sub-scenarios are structured to demonstrate extreme conditions. They illustrate the maximization of the priority use with the available water supply at

the expense of other uses. With the exception of Sub-scenario 3C, in which maximization of the priority use, irrigation, is constrained by attempts to maintain minimum acceptable habitat conditions for fish, no compromises among uses are illustrated.

2. The reservoir storage capacity illustrated in each sub-scenario is that required to maintain acceptable performance of the priority use. This does not apply to sub-scenarios 1B, 1C and 1D.
3. Providing sufficient flow to Saskatchewan to meet Alberta's commitment under the Master Agreement on Apportionment is set as a constraint in all sub-scenarios. The sub-basin apportionment flow allocation illustrated in the sub-scenarios is that required to satisfy Alberta's commitment to Saskatchewan in critical years. In most years, a greater percentage of the flow of each sub-basin than is required to satisfy the apportionment agreement will pass downstream into Saskatchewan.
4. All scenarios are structured to represent future conditions. The current situation is not illustrated.

The amounts of irrigated land and reservoir storage included in each sub-scenario and data on the economic evaluation of irrigation are noted in tables 7.1 to 7.3.



PLANNED IRRIGATION DEVELOPMENT, WITH FUTURE MUNICIPAL AND INDUSTRIAL DEVELOPMENT

The purposes of this scenario are:

1. To establish a Base Case for comparison, which is defined by:
   - the level of irrigation development expected when the water management measures included in the government's 1980 Water Resources and Irrigation Development announcement have been fully implemented (these measures are noted in Chapter 6; page 52);
   - the urban municipal and industrial water requirements and effluents expected in the forseeable future (see Chapter 6, page 51);
   - the existing water management structures plus those included in the 1980 Water Resources and Irrigation Development announcement;
   - secondary treatment of sewage effluents by urban centres, consistent with current government policy;
   - no prescribed allocation of sub-basin flow to apportionment.
2. To illustrate the results, relative to the Base Case, of managing the river system with fish habitat and recreation having priority over irrigation.
3. To illustrate the impact on river water quality of land disposal of the sewage effluent of the cities of Calgary and Lethbridge.

1A - Base Case

Irrigation Development

The results of the Base Case analysis indicate that irrigation in all areas meets the economic performance criteria (see Chapter 6, page 56). The average of the maximum water supply deficits experienced by the various irrigation districts is 5.6%. The net value added to the provincial economy each year associated with the irrigation of 1,440,000 acres of land is $381 million more than would be realized from dryland farming of that land. The agricultural and economic activity associated with the irrigation of this acreage would provide 15,600 more jobs than if the area was dryland farmed.

The cost of additional reservoir storage and of the rehabilitation and expansion of existing headworks and irrigation district works required to support this level of irrigation development is $1,464 million.

Water Quantity

The streamflow conditions for fish habitat are satisfactory throughout the course of the Red Deer River, and in the upper reaches, the cold water fish habitat of the Bow River. Periodic low flow conditions have a severe impact on fish habitat throughout the course of the Oldman River and in the warmwater habitat zone of the Bow River below Bassano Dam.

Boating on the Oldman and its three major tributaries (the St. Mary, Belly and Waterton) suffers major impacts, while boating on the South Saskatchewan, the Bow below Bassano and the Red Deer down-stream from the city of Red Deer is affected by moderate impacts. The major impacts on the Oldman tributaries are common to all sub-scenarios except 1C and 1D. Overall, reservoir recreation experiences a minor negative impact in the Oldman sub-basin, and remains at an acceptable level in the Red Deer and Bow sub-basins. However, major negative impacts on recreation are created on Ghost Reservoir during June and July, St. Mary Reservoir during July and August, and Keho Lake during August. The major impacts on Ghost Reservoir during June and July occur in all sub-scenarios except 1C and 1D.

Water Quality

The water quality conditions identified as having an impact on irrigation are salt concentrations in the South Saskatchewan and in the Oldman below Taber; pathogens in the Bow from Calgary to Bassano Dam and in the Oldman below Lethbridge; and eutrophic conditions below the major urban centres and below Bassano Dam in the Bow.

Fish habitat immediately below the major urban centres on each river suffers major impacts from low oxygen levels and minor impacts from eutrophic conditions. Un-ionized ammonia has a minor impact in the Bow below Calgary and below Bassano Dam, and a major impact in the Oldman from Lethbridge to the mouth and in the South Saskatchewan below Medicine Hat. Water temperatures and dissolved oxygen have major impacts in the Oldman above Lethbridge.

The water quality impacts on contact recreation are attributable to eutrophic conditions in all four rivers, and to pathogens in the Bow from Calgary to Bassano Dam and in the Oldman below Lethbridge. Non-contact recreation is affected by eutrophic conditions in all rivers, and by pathogens in the Bow below Calgary.

Pathogens have a minor impact on municipal use in the Bow between Calgary and Carseland. In the Oldman, sulphates have a major impact below Taber. The minor impacts are due to pathogens below Lethbridge and salts below Taber. Salts and sulphates account for the impact on water for industrial use below Taber in the Oldman River.

The implementation of advanced treatment of the sewage effluent of the major urban centres results in significantly improved water quality. All impacts of pathogens are eliminated and the occurrence of weeds and algae is greatly reduced. The remaining impacts on irrigation are due to weeds and algae in the Bow, and to salts in the Oldman and South Saskatchewan. The major impacts on fish habitat in the lower Bow are caused by un-ionized ammonia and low oxygen levels. The greater concentrations of un-ionized ammonia at the advanced treatment levels occur because weeds and algae, which absorb ammonia, are reduced upstream. In the Oldman, low dissolved oxygen below Lethbridge and un-ionized ammonia from Lethbridge to the mouth account for the major impacts. The impacts on contact recreation are due to weeds and algae. The impacts on municipal and industrial water use in the Oldman are due to salts and sulphates, which come mainly from irrigation return flows.

The capital cost for secondary sewage treatment for this and all sub-scenarios is $115 million. The additional capital cost for advanced sewage treatment is $90 million, for a total of $205 million.

Average Apportionment

On average, 70% of the flow of the South Saskatchewan system would be passed to Saskatchewan, and the average percentage of flow passed by each river would be: Red Deer, 92%; Bow, 67%; Oldman, 58%. In critical years (high demand/low flow) 50% of the flow of the South Saskatchewan would pass into Saskatchewan, and the percentage of its flow passed by each river would be: Red Deer, 76%; Bow, 38%; Oldman, 13%.

1B - Maximum Fish Habitat

Water Management

In this sub-scenario, the maintenance of fish habitat is given priority over irrigation water use.

Irrigation Development

The results of the analysis indicate an economic failure for irrigation in areas supplied with water from the Bow and Oldman river systems. The average of the maximum water supply deficits experienced by the irrigation districts is 50.5%. As a result, the annual net value added to the provincial economy is $282 million – a reduction of $99 million from the Base Case, and 11,250 jobs are created – about 4,350 fewer than in the Base Case. To realize even these reduced benefits would require some measure of economic support for irrigators during critical years to maintain a viable irrigation economy.

To realize the same level of irrigation performance, net value added and job creation in this sub-scenario as in the Base Case, would require the addition of 25,000 acre feet of reservoir storage in the Red Deer sub-basin, 610,000 acre feet in the Bow and 3.9 million acre feet in the Oldman, at a cost of $1.9 billion.

Water Quantity

The streamflow conditions would provide acceptable fish habitat in each of the rivers, and in the case of the Bow and Oldman, the habitat conditions would be a great improvement on the conditions illustrated for the Base Case.

The impacts on boating are acceptable on all major rivers except the Oldman where a moderate impact occurs upstream of Lethbridge. Reservoir recreation is in slightly worse condition than in the Base Case. Major impacts exist on Keho Reservoir throughout the summer, on Ghost Reservoir during June and July, and on St. Mary Reservoir during August. Moderate negative impacts during June affect Dickson Reservoir and Chain Lakes.

Water Quality

The diluting effect of the

greater streamflows that are required to maintain fish habitat in this sub-scenario, results in water quality conditions at the secondary treatment level that are somewhat better than illustrated in the Base Case.

Weeds and algae in all rivers and pathogens downstream from Calgary on the Bow and from Lethbridge on the Oldman account for the minor impacts on irrigation. The increased flows eliminate the salt problems in the Oldman and South Saskatchewan.

The major impact on fish habitat immediately downstream from the major urban centres on all rivers results from low dissolved oxygen; the minor impacts are due to weeds and algae. Ammonia has a minor impact on fish habitat immediately below Calgary on the Bow, but has no impact elsewhere. Water temperature has a minor impact in the Oldman above Lethbridge. The impacts on recreation are the same as in the Base Case. The minor impact on water for municipal use in the Bow is due to pathogens.

The implementation of advanced treatment of the sewage effluents of all the major urban centres reduces or eliminates most of the water quality impacts in this sub-scenario. Weeds and algae continue to have an impact on contact recreation in all rivers, and on irrigation and fish below Bassano Dam in the Bow. The major impact on fish habitat in the Bow is low dissolved oxygen.

The cost of secondary sewage treatment for this sub-scenario is $115 million; the additional cost of advanced sewage treatment is $90 million for a total of $205 million.

Average Apportionment

On average, 73% of the flow of the South Saskatchewan system would be passed to Saskatchewan, and the average percentage of flow passed by each river would be: Red Deer, 90%; Bow, 70%; Oldman, 65%. In critical years, the percentage of flow passed by each river would be: Red Deer, 69%; Bow, 53%; Oldman, 42%.

The percentages of flow passed in average years are not much different than in the Base Case. However, in the critical years the Bow and Oldman pass substantially greater percentages of flow than in the Base Case, which accounts for the failure of irrigation in this sub-scenario.

1C - Maximum Recreation Conditions

Water Management

In this sub-scenario the maintenance of conditions best-suited for recreation is given priority over irrigation water use. Irrigation is given priority over the maintenance of fish habitat.

Irrigation Development

The results of the analysis indicate a failure for irrigation in areas supplied with water from the Bow and Oldman river systems. The average of the maximum water supply deficits experienced by all the irrigation districts in the basin is 32%. As a result, the annual net value added to the provincial economy is $321 million – a reduction of $60 million from the Base Case, and about 12,900 jobs are created – 2,700 fewer than in the Base Case. To realize even these reduced benefits would require some measure of economic support for irrigators supplied from the Bow and Oldman systems during critical years to maintain a viable irrigation economy.

To realize the same level of irrigation performance, net value added and job creation in this sub-scenario as in the Base Case, would require the addition of 210,000 acre feet of storage in the Bow subbasin and 2.1 million acre feet in the Oldman, at a cost of $1.2 billion.

Water Quantity

The maintenance of streamflows suitable for river recreation does not result in any improvement in the fish habitat conditions experienced in the Base Case. Habitat conditions remain favourable in the Red Deer River above Red Deer and in the upper Bow. Flow conditions have a moderate impact on fish in the lower Red Deer River. Periodic low flows have a severe impact on fish in the lower Bow and throughout the course of the Oldman.

There are substantial improvements in water quantity conditions for recreation over the Base Case. Conditions on the four main rivers are acceptable for boating. Of the other three rivers evaluated, only the Waterton River during July and August has major impacts on boating. Reservoir recreation is affected by negative impacts on two reservoirs: Dickson Reservoir and Keho Lake, with only Keho Lake during July and August experiencing major impacts.

Water Quality

With secondary treatment of municipal sewage effluent, water quality conditions are somewhat improved over the Base Case. The diluting effect of the greater streamflow in the Oldman River required to maintain suitable conditions for river recreation in the summer and early fall eliminates the impact of salts and sulphates on irrigation, municipal and industrial use, and the impact of ammonia on fish habitat. Irrigation suffers minor impacts from pathogens downstream from Calgary in the Bow and downstream from Lethbridge in the Oldman, and from weeds and algae downstream from the major urban centres in all rivers.

Water quality conditions in the Bow have major impacts on fish habitat due to low

dissolved oxygen and minor impacts due to ammonia, weeds and algae. Water temperatures have a minor impact on fish habitat in the Oldman above Lethbridge. Below Lethbridge, low dissolved oxygen has a major impact and weeds and algae have a minor impact. In the South Saskatchewan below Medicine Hat, low dissolved oxygen and ammonia have a major impact on fish habitat. Weeds and algae have a minor impact.

Contact recreation suffers major impacts from pathogens in the Bow below Calgary and in the Oldman below Lethbridge, and major impacts from weeds and algae in all rivers. Non-contact recreation is affected by weeds and algae in all rivers, and by pathogens in the Bow below Calgary. Pathogens have a minor impact on municipal water supplies in the Bow between Calgary and Carseland weir.

The implementation of advanced treatment of the sewage effluent of the major urban centres would reduce or eliminate most of the water quality impacts in this sub-scenario. Weeds and algae continue to have a major impact on contact recreation in the lower reaches of all rivers, and a minor impact on irrigation and fish habitat at the mouth of the Bow. The remaining major impacts on fish habitat are due to low dissolved oxygen and ammonia in the Bow immediately below Bassano Dam.

The cost of secondary sewage treatment for this sub-scenario is $115 million. The additional cost of advanced sewage treatment is $90 million, for a total of $205 million.

Average Apportionment

On average, 72% of the flow of the South Saskatchewan system would be passed to Saskatchewan, and the percentage of flow passed by each river would be: Red Deer, 91%; Bow, 63%; Oldman, 69%. In the critical years, the flow passed by each river would be: Red Deer, 75%; Bow, 44%; Oldman, 43%.

The significant increase from the Base Case in the flow passed by the Oldman during critical years explains the economic failure in irrigation districts supplied from the Oldman.

1D - High Priority Recreation

Water Management

In this sub-scenario the maintenance of conditions best-suited for recreation in reservoirs and river reaches considered to be of the highest priority for recreational use is given priority over irrigation. Irrigation is given priority over the maintenance of fish habitat.

The river reaches and reservoirs considered to be of high priority for this scenario include: the Red Deer River below Red Deer, the Bow River above Carseland weir, the Oldman River above Lethbridge, and the following reservoirs: Dickson on the Red Deer River; Minnewanka, Barrier, Upper Kananaskis, Lower Kananaskis, Ghost, Chestermere, McGregor, Travers and Little Bow in the Bow system; and Chain Lakes, Paine, Jensen and St. Mary in the Oldman system.

Irrigation Development

The results of the analysis indicate an economic failure for irrigation in the areas supplied with water from the Oldman River system. The average of the maximum water supply deficits experienced by all irrigation districts in the basin is 21.9%. As a result, the annual net value added to the provincial economy is $357 million – a reduction of $24 million from the Base Case, and 14,500 jobs are created – 1100 fewer than in the Base Case. To realize even these reduced benefits would require some measure of economic support for irrigators in the Oldman basin to sustain a viable irrigation economy.

To realize the same level of irrigation performance, net value added and job creation in this sub-scenario as in the Base Case, would require an additional 130,000 acre feet of storage in the Oldman sub-basin, at a cost of $148 million.

Water Quantity

Streamflow conditions for fish habitat are the same in this sub-scenario as in Sub-scenario 1C: satisfactory in the upper Bow and Red Deer, a moderate impact in the lower Red Deer, and severe impacts in the lower Bow and throughout the course of the Oldman.

Water quantity conditions for recreation are generally better than in the Base Case. Except for Dickson, none of the river reaches or reservoirs with high recreation value experience negative impacts. The South Saskatchewan River below Medicine Hat is in slightly better condition for boating than in the Base Case. Keho Lake and Waterton Reservoir are affected by major impacts during July and August. Dickson Reservoir in June and Ridge Reservoir in August suffer moderate impacts.

Water Quality

Water quality conditions for all uses at both the secondary and advanced levels of sewage treatment are the same as those in Sub-scenario 1C – a marked improvement over the Base Case.

The cost of secondary sewage treatment for this sub-scenario is $115 million. The additional cost for advanced sewage treatment is $90 million, for a total of $205 million.

Average Apportionment

On average 70% of the flow of the South Saskatch-

ewan system would be passed to Saskatchewan, and the percentage of flow passed by each river would be: Red Deer, 90%; Bow, 62%; Oldman, 66%. In critical years, the percentage of flow passed by each river would be: Red Deer, 75%; Bow, 37%; Oldman, 40%.

As in Sub-scenario 1C, the significant increase from the Base Case in the flow passed by the Oldman during critical years explains the economic failure of irrigation in the basin.

1E - Land Disposal of Sewage Effluent

Water Management

This sub-scenario illustrates some of the effects of land disposal of the sewage effluent from the cities of Calgary and Lethbridge through irrigation or rapid infiltration.

In this sub-scenario Calgary's sewage effluent is used to irrigate 203,000 acres of land in a new irrigation district located in the Little Bow River Basin south of Calgary. Costs and revenues were estimated accordingly. No particular method was established for the land disposal of Lethbridge's sewage effluent, and the only result illustrated is the effect on water quality of reducing Lethbridge's sewage discharge to zero.

Irrigation Development

The results of the analysis of this sub-scenario indicate that the economic performance of irrigation is satisfactory. A total of 1,642,600 acres is irrigated, an increase of 203,000 acres over the Base Case. Consequently, the average of the maximum water supply deficits experienced by irrigators increases slightly to 9.1%. The annual net value added to the provincial economy is $420 million, an increase of $39 million over the Base Case. The number of jobs resulting directly or indirectly from irrigation increase by 1500 over the Base Case to 17,100. All of the irrigation-related increases indicated are attributable to the use of Calgary's sewage effluent for irrigation.

Water Quantity

Streamflow conditions for fish habitat are the same as in the Base Case: suitable throughout the course of the Red Deer and in the Bow above Bassano Dam, severe impacts in the lower Bow and throughout the course of the Oldman River.

The water quantity conditions for recreation are essentially equal to the Base Case. On the four major rivers, the only change that affects boating is a decline from moderate to major impacts on the Bow below Bassano. Reservoir recreation in the Oldman sub-basin is, overall, affected by minor negative impacts. Compared to the Base Case, only recreation at Keho Lake during June is subjected to worse water supply conditions, with the level of impact deteriorating from minor to moderate.

Water Quality

The water quality conditions at the secondary treatment level are those experienced in the Base Case. With the implementation of land disposal of sewage effluent from Calgary and Lethbridge, together with advanced sewage treatment at Red Deer and Medicine Hat, the water quality conditions illustrated are a slight improvement over the Base Case. In the Bow below Bassano the major impact of un-ionized ammonia on fish habitat is eliminated, although the major impact of low dissolved oxygen remains. In the Oldman below Lethbridge, the impact of un-ionized ammonia on fish habitat is reduced from major to minor, and the impact of low dissolved oxygen is eliminated; the impact of weeds and algae on recreation is reduced.

The cost of secondary sewage treatment for this scenario is $115 million. The additional costs for advanced treatment at Red Deer and Medicine Hat are $10 million. The expenditures required to make Calgary's sewage effluent available for irrigation are $654 million for a total of $779 million. There would be additional costs for land disposal of Lethbridge's sewage effluent.

Average Apportionment

On average, 67% of the flow of the South Saskatchewan system would pass to Saskatchewan, and the percentage of flow passed by each river would be: Red Deer, 92%; Bow, 61%; Oldman, 58%. In critical years, the percentage of flow passed by each river would be: Red Deer, 76%; Bow, 34%; Oldman, 20%.

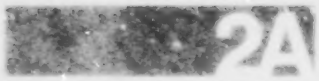
Scenario 2

REGIONAL DEVELOPMENT

The purpose of this scenario is to illustrate the probable results of future water use and management strategies directed primarily at contributing to regional development.

The irrigated acreage in areas served by existing irrigation districts, and municipal and industrial water uses are held at the Base Case level in all sub-scenarios. The amount and location of additional irrigated acreage differs for each sub-scenario, as indicated in Table 7.1. Areas where there is an apparent demand for irrigation development were selected to illustrate regional irrigation expansion in this scenario. These are: the Little Bow River basin, the Special Areas and the Blackfoot, Peigan and Blood Indian Reserves.

Irrigation water use has priority over fish habitat and recreational use in all sub-scenarios, and each sub-scenario illustrates the results of a different combination of apportionment flow allocation and reservoir storage options.



2A - Irrigation Allocation/No Additional Storage

Water Management

This sub-scenario illustrates the results that could be expected if the sub-basin apportionment flow allocation was set at: Red Deer, 75%; Bow, 40%; Oldman, 40%; and there was no addition to the storage illustrated in the Base Case.

Irrigation Development

In this sub-scenario the irrigated acreage has been increased by 190,000 acres over the Base Case. The additional acreage is distributed among the five regions, and draws on water supplies from the Red Deer, Bow and Oldman river systems (See Table 7.1)

The analysis indicates that irrigation satisfies the economic performance criteria, although the average maximum water supply deficit, at 21.6%, has increased substantially over the 5.6% noted in the Base Case. The annual net value added and the number of jobs created are about 10% greater than in the Base Case.

The cost of the reservoir storage, rehabilitation and expansion of headworks and irrigation district works necessary to support this level of irrigation development is $1,717 million, $253 million more than for the Base Case.

Water Quantity

Due to the greater critical year apportionment flow allocation for the Oldman, streamflow conditions have a moderate impact on fish habitat in the Oldman below Lethbridge, compared to the severe impact noted in the Base Case. In the other river reaches, streamflow conditions for fish habitat are unchanged from the Base Case.

Boating on rivers improves slightly over the Base Case. A decline in conditions for boating on the Bow is offset by improvements in the Red Deer and Oldman below the major urban centres. In the Red Deer, however, there is a deterioration in flows below Dinosaur Provincial Park that causes major impacts on boating during July and August. Reservoir recreation undergoes a slight decline from the Base Case. In addition to the Base Case impacts, major impacts occur on Dickson Reservoir during June and Keho Lake during June and July thus subjecting Keho Lake to major negative impacts throughout the summer. The overall minor impact on reservoirs in the Bow sub-basin is due to the usual June and July major impacts on Ghost Reservoir and minor negative impacts on Chestermere Lake throughout the summer.

Water Quality

At the secondary sewage treatment level the water quality conditions are generally similar to those in the Base Case. The exceptions are the occurrence of a minor impact on irrigation from salts at the mouth of the Bow, and major impacts on fish from ammonia at the mouth of the Bow. The improvements in water quality for fish habitat in the Oldman are due to the reduction or elimination of unionized ammonia. The impact of pathogens, salts and sulphates on municipal and industrial use in the Oldman are eliminated, as are the impacts of low dissolved oxygen on fish habitat above Lethbridge. The poorer conditions for fish habitat in the South Saskatchewan are due to decreased dissolved oxygen.

Water quality conditions in the Oldman are an improvement on the Base Case, because the greater percentage of streamflow allocated to apportionment in critical years means that flows in the Oldman are higher in those years than they are in the Base Case.

Water quality conditions with advanced sewage treatment are similar to conditions at that level of treatment in the Base Case. The exceptions are a minor salt impact on irrigation at the mouth of the Bow, and elimination of the dissolved oxygen and ammonia impacts on fish habitat in the Oldman.

The cost of secondary and advanced sewage treatment for this sub-scenario is the same as for the Base Case.

Average Apportionment

On average, 67% of the

flow of the South Saskatchewan system would pass into Saskatchewan, and the percentage of flow passed by each river would be: Red Deer, 86%; Bow, 65%; Oldman, 57%.

2B - Irrigation Allocation/Additional Storage

Water Management

This sub-scenario illustrates the results that could be expected if the critical year sub-basin apportionment flow allocation was set at: Red Deer, 75%; Bow, 40%; Oldman, 40%; and additional reservoir storage is built into the system.

Irrigation Development

In this sub-scenario the irrigated acreage has been increased by 270,500 acres over the Base Case. The regional development area irrigated from the Bow River is the same as in 2A (about 97,000 acres); the area irrigated from the Red Deer is increased to 128,500 acres, about double that in 2A; the area irrigated from the Oldman has been increased by about one-third from 2A to 45,000 acres.

The analysis indicated that the economic performance criteria for irrigation are satisfied. The average maximum water supply deficit, at 21.2%, is similar to that in 2A and substantially more than in the Base Case. The annual net value added is $57 million more than in the Base Case and 2200 more jobs are created.

The additional reservoir storage included in this sub-scenario is 90,000 acre feet in the Oldman sub-basin and 810,000 acre feet in the Red Deer.

The total cost of reservoir storage and rehabilitation and expansion of headworks and district works necessary to support this level of irrigation development is $2,287 million, $823 million more than for the Base Case.

Water Quantity

With the exception of the lower Oldman, streamflow conditions for fish habitat are the same as in the Base Case. Because the Oldman passes a greater percentage of its flow to apportionment in this sub-scenario, streamflow conditions have a moderate impact on fish habitat in the lower Oldman compared to a severe impact in the Base Case.

Water quantity conditions for recreation in this sub-scenario are very similar to conditions in the previous sub-scenario (2A). The impact on boating below the city of Red Deer is acceptable, while below Dinosaur Provincial Park the major impact occurs only during July. There is also a slight improvement in boating conditions compared to 2A in the Oldman below Taber. Conditions for reservoir recreation are slightly worse than in 2A for the Oldman sub-basin where, although the overall impact is minor, the impact on Waterton and St. Mary during June has increased from minor to moderate.

Water Quality

Water quality conditions at the secondary sewage treatment level are the same as in 2A and generally similar to the Base Case: a slight deterioration in quality in the Bow below Bassano Dam and in the South Saskatchewan below Medicine Hat, and improvements in the Oldman.

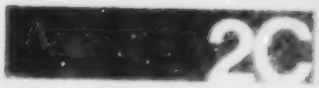
Water quality conditions in the Oldman are an improvement on the Base Case, because the greater percentage of streamflow allocated to apportionment in critical years means that flows in the Oldman are higher in those years than they are in the Base Case.

Water quality conditions with advanced sewage treatment are the same as in 2A, which illustrates improved conditions for fish habitat compared to the Base Case.

The costs of secondary and advanced sewage treatment for this sub-scenario are the same as for the Base Case.

Average Apportionment

On average, 66% of the flow of the South Saskatchewan system would pass into Saskatchewan; the percentage of flow passed by each river would be: Red Deer, 80%; Bow, 65%; Oldman, 56%.



2C - Equal Allocation/ Additional Storage

Water Management

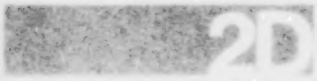
This sub-scenario illustrates the results that could be expected if the critical year sub-basin apportionment flow allocation was set at: Red Deer, 50%; Bow, 50%; Oldman, 50%; and no additional reservoir storage was built into the system.

Irrigation Development

In this sub-scenario the irrigated acreage has been increased by 155,700 acres over the Base Case. All of the additional irrigated acreage is located in the vicinity of the Special Areas, and is supplied with water from the Red Deer river system.

The analysis indicates that the economic performance criteria for irrigation are satisfied in areas supplied with water from the Red Deer system. However, in areas supplied with water from the Bow or Oldman system, irrigation fails to meet the criteria. Since the acreage irrigated from the Bow and Oldman in this sub-scenario is the same as in the Base Case, it is apparent that economic success at the planned level of irrigation development cannot be realized if each sub-basin is required to contribute 50% of its flow to apportionment, without additional reservoir

storage in the Bow and Oldman systems.



2D - Equal Allocation/ Additional Storage

Water Management

This sub-scenario illustrates the results that could be expected if the sub-basin flow allocation was set at: Red Deer, 50%; Bow, 50%; Oldman, 50%; and additional reservoir storage was added to the system.

Irrigation Development

In this sub-scenario the irrigated acreage has been increased by 389,100 acres over the Base Case, all in regional development areas. The increased acreage served from each river system is: from the Red Deer, 247,100 (in the vicinity of the Special Areas); from the Bow, 97,000 (in the Little Bow basin and the Blackfoot Indian Reserve); from the Oldman, 45,000 (in the Blood and Peigan Indian Reserves).

The analysis indicates that irrigation satisfies the economic performance criteria. The average maximum water supply deficit is 16.4%. The annual net value added and the number of jobs created are about 25% greater than in the Base Case.

The additional reservoir storage required to support irrigation development in this sub-scenario is 575,000 acre feet in the Red Deer sub-basin, 560,000 acre feet in the Bow and 2,240,000 acre feet in the Oldman.

The total cost of the reservoir storage and rehabilitation and expansion of headworks and district works required to support irrigation is $3,647 million, an increase of $2,183 million over the Base Case.

The extraordinarily large amount of storage required to support the area irrigated from the Oldman River system, an increase of only 45,000 acres from the Base Case, indicates the effect of allocating 50% of the flow of the Oldman system to apportionment. As illustrated in Sub-scenario 2B, the same increase in acreage can be supported with 90,000 acre feet of storage if only 40% of the flow of the Oldman system is allocated for apportionment.

Water Quantity

Streamflow conditions impose a severe impact on fish habitat in the lower reaches of the Red Deer River. This deterioration from the acceptable habitat conditions illustrated in the Base Case is due to the lesser apportionment allocation and the greater withdrawals required to support the eight-fold increase in irrigated acreage in this sub-scenario. Conditions on the Bow are the same as in the Base Case; satisfactory in the cold water habitat zone, but suffering a severe impact in the warm water zone below Bassano Dam. As in the Base Case, streamflow conditions have a severe impact in the coldwater habitat zone in the Oldman, but the greater allocation of streamflow to apportionment in this sub-scenario results in some improvement in conditions in the warmwater habitat zone in the lower reaches of the river.

The water quantity conditions for boating are better than in the Base Case for two river reaches: the Oldman River from Lethbridge to the mouth and the South Saskatchewan River. On the Red Deer River, conditions for boating remain moderately negative overall, but an improvement in conditions below the city of Red Deer has been nullified by a shift from moderate to major impacts below Dinosaur Provincial Park. Reservoir recreation in the basin is subject to worse conditions than in the Base Case. Water supply at Dickson Reservoir declines to moderately negative levels while low water levels on Chestermere Lake during August cause the overall recreation rating for reservoirs in the Bow sub-basin to slip from acceptable to a minor impact. In the Oldman sub-basin, deterioration to major impacts throughout the summer on Keho Lake are offset by improvements in water levels during July and August on St. Mary Reservoir.

Water Quality

Compared to the Base Case, water quality conditions with secondary treatment of municipal sewage effluent are somewhat improved in the Oldman, where higher flows downstream from Lethbridge reduce or eliminate the impact of ammonia on fish habitat and the impact of salts and sulphates on municipal and industrial use. Conditions for fish habitat are improved in the Bow below Calgary due to the elimination of un-ionized ammonia. In the Bow below Bassano Dam conditions are somewhat

worse than in the Base Case due to the increased occurrence of salts, which have a minor impact on irrigation use, and un-ionized ammonia, which has a major impact on fish habitat. In the South Saskatchewan conditions are worse than in the Base Case, due to the impact of lower dissolved oxygen levels on fish habitat.

With advanced treatment of municipal sewage, water quality conditions for fish habitat in the Oldman are better than in the Base Case. In the Bow, conditions are comparable to the Base Case, although salts present a minor problem for irrigation near the mouth.

Streamflow in the lower Red Deer during the low flow years in this sub-scenario was not sufficient for reliable application of the water quality model. Because of the low streamflow, water quality conditions below Dinosaur Park in low flow years would be worse than in the Base Case. Major impacts on all uses could be expected.

The costs of secondary and advanced sewage treatment in this sub-scenario are the same as in the Base Case.

Average Apportionment

On average, 63% of the flow of the South Saskatchewan system would pass into Saskatchewan; the percentage of flow passed by each river would be: Red Deer, 68%; Bow, 64%; Oldman, 56%.

Scenario 3

REGIONAL DEVELOPMENT AND IRRIGATION DISTRICT EXPANSION

The purposes of this scenario are to illustrate the probable results of water use and management strategies directed primarily at:

- achieving some degree of both regional irrigation development and expansion of irrigation in areas served by existing irrigation districts, and
- achieving some degree of regional and district irrigation expansion while maintaining acceptable fish habitat.

In all sub-scenarios, irrigation water use has priority over fish habitat and recreational use, and the sub-basin apportionment flow allocations are set at levels approximating the present condition: Red Deer, 75%; Bow, 40%; Oldman, 40%.

Municipal and industrial water use is held at the Base Case level in all sub-scenarios. The amount and location of the irrigated acreage differs for each sub-scenario as indicated in Table 7.1. The areas selected to illustrate regional irrigation development are the same as in Scenario 2.

3A

3A - Irrigation Allocation/Minimum Additional Storage

Water Management

This sub-scenario illustrates the conditions that could be expected if the irrigated acreage in the basin was increased, through regional and district expansion, by about 15% (188,250 acres) over the Base Case.

Irrigation Development

About one-half of the irrigation expansion is in existing districts and one-half in regional development areas. The additional acreage supplied from each river is: Red Deer, 24,700; Bow, 145,200; Oldman, 18,350.

The analysis indicates that irrigation satisfies the economic performance criteria. The average maximum water supply deficit is 16%. The annual net value added is $423 million, an increase of $42 million over the Base Case. There are 17,200 jobs created, an increase of 1600 over the Base Case.

The additional reservoir storage required is 220,000 acre feet in the Bow system to support an irrigation expansion of 145,200 acres. The total cost of the reservoir storage and rehabilitation and expansion of headworks and district works required to support irrigation at this level is $1,875 million, an increase of $411 million over the Base Case.

Water Quantity

Streamflow conditions for fish habitat are comparable to the Base Case in all rivers, except in the lower reaches of the Oldman where the impact has improved from severe to moderate. This improvement is due to the higher critical year flows in the Oldman that result from allocating 40% of the flow of that river for apportionment.

Water quantity conditions for boating are improved slightly over the Base Case. The Bow below Bassano has become worse for boating, but conditions in the Red Deer below the city of Red Deer and in the Oldman below Lethbridge have improved. Conditions for recreation on Dickson Reservoir have dropped from acceptable to a minor impact, while Keho Lake experiences major negative impacts throughout the summer rather than just during August.

Water Quality

Water quality conditions at the secondary sewage treatment level have changed from the Base Case. In the Bow below Bassano Dam, the impact on irrigation due to salts, and on fish due to ammonia, are greater during low flow years. In the Oldman, the impacts of un-ionized ammonia on fish habitat are reduced or eliminated. The impacts of pathogens, salts and sulphates on municipal and industrial use are also

eliminated.

Advanced sewage treatment improves water quality conditions for fish habitat in the Oldman.

The costs of secondary and advanced sewage treatment in this sub-scenario are the same as in the Base Case, $205 million.

Average Apportionment

On average, 67% of the flow of the South Saskatchewan system would pass into Saskatchewan; the percentage of flow passed by each river would be: Red Deer, 90%; Bow, 61%; Oldman, 57%.

3B - Irrigation Allocation/Moderate Additional Storage

Water Management

This sub-scenario illustrates the conditions that could be expected if the irrigated area is increased by about 20% (292,850 acres) over the Base Case.

Irrigation Development

About one-half of the additional irrigated acreage is in areas served by existing irrigation districts, and one-half in regional development areas. The additional acreage supplied from each river system is: Red Deer, 74,100; Bow, 198,400; Oldman, 28,350; South Saskatchewan, 4300.

The analysis indicates that irrigation satisfies the economic performance criteria, although the average maximum water supply deficit is 22.4%. Both the annual net value added and the number of additional jobs are about 20% greater than in the Base Case.

The additional reservoir storage required is 400,000 acre feet in the Bow system and 200,000 acre feet in the Oldman system. The total cost of the additional reservoir storage and rehabilitation and expansion of headworks and district works required to support irrigation at this level is $2,137 million, an increase of $673 million over the Base Case.

Water Quantity

Streamflow conditions for fish habitat are comparable to the Base Case. Due to the higher critical year flows in the lower Oldman, the impact on fish habitat is moderate rather than severe.

Water quantity conditions for boating in this sub-scenario are a slight improvement over the Base Case. Flows for boating on the Red Deer River are improved below the city of Red Deer, but below Dinosaur Park, low flows have major negative impacts on boating during July and August. Conditions for boating are worse in the Bow below Bassano Dam, but better in the Oldman below Lethbridge. The conditions for reservoir recreation have changed slightly from the Base Case. Water levels in Dickson Reservoir create a major negative impact on recreation during June, while water supply conditions at Keho Lake have deteriorated so that major impacts occur throughout the summer.

Water Quality

Water quality conditions at the secondary sewage treatment level have changed from the Base Case. In the Bow below Bassano Dam, the impact on irrigation, due to salts, and on fish due to ammonia, are greater during low flow years. In the Oldman, the impacts of un-ionized ammonia on fish habitat are reduced or eliminated. The impacts of pathogens, salts and sulphates on municipal and industrial use are also eliminated. In the South Saskatchewan conditions for fish are worse than in the Base Case due to lower dissolved oxygen levels.

Advanced sewage treatment improves water quality conditions for fish habitat in the Oldman.

The costs of secondary and advanced sewage treatment in this scenario are the same as in the Base Case.

Average Apportionment

On average, 65% of the flow of the South Saskatchewan system would pass into Saskatchewan. The percentage of flow passed by each river would be: Red Deer, 87%; Bow, 59%; Oldman, 57%.

3C - Irrigation Allocation/Moderate Additional Storage/ Fish Habitat Maintenance

Water Management

The sub-scenario illustrates some relationships between irrigation expansion, reservoir storage capacities and the maintenance of fish habitat. The irrigated acreage has been increased by the same amount, 188,250 acres, and in the same proportions relative to each river system as in 3A. However, the additional reservoir storage is increased to the greater capacities illustrated in 3B: 400,000 acre feet in the Bow system and 200,000 acre feet in the Oldman system.

Irrigation Development

The annual net value added is approximately the same as in 3A. However the cost of additional reservoir storage is $161 million more than in 3A. This cost difference can be considered as the cost of storage devoted to the maintenance of fish habitat.

The cost of reservoir storage and rehabilitation and expansion of headworks and district works is $2,036 million, an increase of $572 million over the Base Case.

Water Quantity

Despite nearly doubling

reservoir storage in the Bow and Oldman systems, streamflow conditions for fish habitat are only marginally better than in 3A. Compared to the Base Case, habitat conditions are better in warmwater habitat zones in the lower Bow and lower Oldman, where the impacts are reduced from severe to moderate.

Higher flows in this subscenario improve the conditions for boating compared to the Base Case on the Red Deer below the city of Red Deer, on the Oldman below Lethbridge, and on the South Saskatchewan River. A decline from the Base Case conditions for reservoir recreation occurs due to a moderate negative impact during June at Dickson Reservoir and to major negative impacts at Keho Lake throughout the summer.

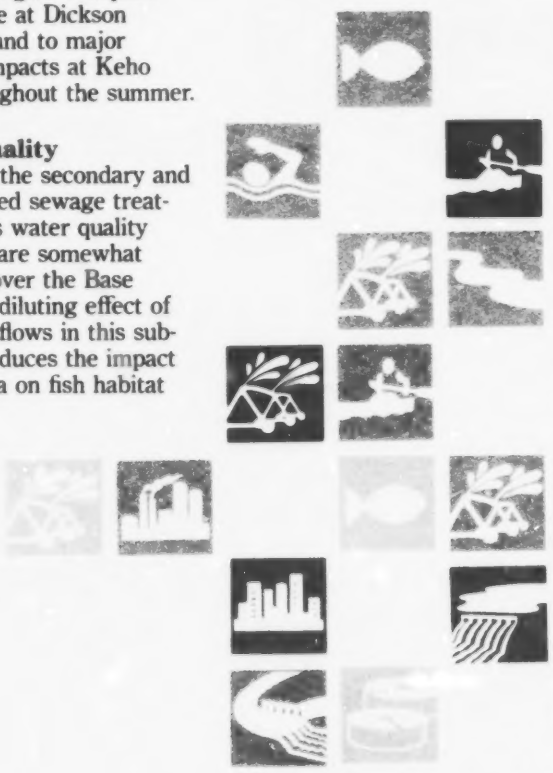
Water Quality

At both the secondary and the advanced sewage treatment levels water quality conditions are somewhat improved over the Base Case. The diluting effect of the higher flows in this subscenario reduces the impact of ammonia on fish habitat and eliminates the impacts caused by salts and sulphates that are evident in the Base Case. With advanced treatment, the impacts of ammonia and dissolved oxygen on fish habitat in the Oldman are eliminated.

The costs for secondary and for advanced sewage treatment are the same as for the Base Case.

Average Apportionment

On average, 67% of the flow of the South Saskatchewan system would pass into Saskatchewan; the percentage of flow passed by each river would be: Red Deer, 91%; Bow, 61%; Oldman, 57%.



Scenario 4

MAXIMUM IRRIGATION EXPANSION

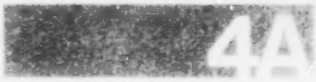
The purposes of this scenario are to illustrate:

- the probable results of water use and management strategies directed primarily at achieving the maximum expansion of the irrigated acreage in areas that could be served by feasible extension of the works of existing irrigation districts, and
- the apparent limits of irrigation expansion with the water supply in the South Saskatchewan river system.

In all sub-scenarios, irrigation water use has priority over fish habitat and recreational use. Municipal and industrial water use is held at the Base Case level.

The amount and distribution of the irrigated acreage differs in each sub-scenario as indicated in Table 7.1. All sub-scenarios include expansion of private irrigation to about 30,000 acres in each sub-basin.

In the sub-scenarios that illustrate the maximum possible expansion of irrigation in the basin, acreage in excess of that which could be supplied by feasible extension of the works of existing districts was placed in "new" districts, located where possible in the agro-climatic zones that offer the greatest economic return to irrigation.



4A - Maximum District Expansion/ Irrigation Allocation/ No Additional Storage

Water Management

This sub-scenario illustrates the extent to which existing irrigation districts could expand if the percentage of the flow of each river allocated to apportionment was set at: Red Deer, 90%; Bow, 30%; Oldman, 30%; but with no additions to the reservoir storage illustrated for the Base Case.

Irrigation Development

The analysis indicates that the irrigated area supplied with water from the Bow River is increased to 734,500 acres. This is not sufficient to support maximum expansion of irrigation in the area that could be served by the extension of the works of existing districts supplied from the Bow, 823,000 acres. The area irrigated with water from the Oldman system is increased to 811,000 acres. This is sufficient to support expansion to the maximum acreage that could be served by extension of the works of existing districts supplied from the Oldman system, 781,000 acres. In total, the irrigated acreage is increased by 185,890 acres over the Base Case (See Table 7.1).

Irrigation at this level would satisfy the economic performance criteria. The average maximum water supply deficit would be 19.4%. The annual net value added and the number of jobs created would increase by about 10% over the Base Case.

The cost of reservoir storage and rehabilitation and enlargement of headworks and district works required to support this level of irrigation development would be $1,560 million, an increase of $96 million over the Base Case.

Water Quantity

Streamflow conditions for fish habitat would be the same as in the Base Case.

Water quantity conditions for recreation in this sub-scenario have changed from the Base Case in several ways. In the Red Deer sub-basin, there are major impacts at Dickson Reservoir throughout the summer, but the higher river flows reduce the impact on boating in the Red Deer downstream from the city of Red Deer. In the Bow sub-basin, general conditions for reservoir recreation are slightly worse because of a poorer water supply situation in Chestermere Lake during July and August, while conditions for boating have a major impact on the Bow below Bassano Dam. There is also a general deterioration in conditions for reservoir recreation in the Oldman sub-basin that accounts for a 25% increase in the number of months when water supply is unacceptable for recreation.

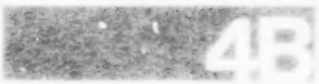
Water Quality

Water quality conditions at both the secondary and advanced sewage treatment levels are comparable to the Base Case. The exceptions are a greater impact of ammonia concentrations on fish habitat in the Bow below Bassano Dam, and a major impact from sulphates on municipal use in the Oldman below Taber.

The costs of secondary and advanced sewage treatment are the same as for the Base Case.

Average Apportionment

On average, 67% of the flow of the South Saskatchewan system would pass into Saskatchewan; the percentage of flow passed by each river would be: Red Deer, 92%; Bow, 61%; Oldman, 57%.



4B - Maximum District Expansion/Irrigation Allocation/Additional Storage

Water Management

This sub-scenario illustrates the additional reservoir storage that would be required to support the acreage that could be served by maximum extension of the works of existing irrigation districts, if the percentage of the flow of each river allocated to apportionment was set at: Red Deer, 90%; Bow, 30%; Oldman, 30%.

Irrigation Development

As illustrated in 4A, the maximum area that can be served by extension of the works of existing districts supplied with water from the Oldman system is 781,000 acres, and this can be achieved with no addition to the reservoir storage included in the Base Case. The analysis of this sub-scenario indicates that the maximum acreage that can be served by extension of the works of districts supplied with water from the Bow River system, 823,000 acres, can be achieved with the addition of 650,000 acre feet of storage. In total, the irrigated acreage is increased by 334,390 acres over the Base Case. The distribution of this acreage is shown in Table 7.1.

The economic performance criteria for irrigation would be satisfied at this level of development. The average maximum water supply deficit would be 16.4%. The annual net value added and the number of jobs would be 20% greater than in the Base Case.

The cost of reservoir storage and rehabilitation and enlargement of headworks and districts works required to support this level of irrigation development would be $2,161 million, an increase of $697 million over the Base Case.

Water Quantity

Streamflow conditions for coldwater fish habitat in the Bow River below Calgary, which are acceptable in the Base Case, suffer a moderate impact in this sub-scenario. Impacts in the lower Oldman are reduced from severe to moderate. In the Red Deer, conditions are the same as in the Base Case.

Water supply for boating is worse than the Base Case in the Bow below Bassano and in the Red Deer upstream of the city of Red Deer; it is improved in the Red Deer below Dinosaur Provincial Park. Conditions for recreation at Dickson Reservoir, where lower water levels boost the impact during June from minor to major, are poorer than in the Base Case. The only other water body that undergoes a significant change from the Base Case is Keho Lake which experiences more severe impacts during June and July.

Water Quality

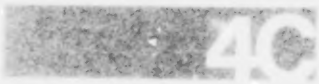
Water quality conditions at both the secondary and advanced sewage treatment levels are comparable to the Base Case. The exceptions are a greater impact of ammonia concentrations on fish habitat in the Bow below Bassano Dam, and a major impact from sulphates on municipal use in the Oldman below Taber. The impacts of salts on irrigation in the South Saskatchewan are eliminated due to the higher flow required to meet apportionment in critical years.

The costs of secondary and advanced sewage treat-

ment are the same as for the Base Case.

Average Apportionment

On average, 64% of the flow of the South Saskatchewan system would pass into Saskatchewan; the percentage of flow passed by each river would be: Red Deer, 97%; Bow, 52%; Oldman, 57%.



4C - Maximum Irrigation Expansion/ Irrigation Allocation/ Maximum Additional Storage

Water Management

This sub-scenario illustrates the maximum acreage that could be irrigated with the water supply of the South Saskatchewan River system, if the percentage of the flow of each river allocated to apportionment was set at: Red Deer, 90%; Bow, 30%; Oldman, 30%; and if the maximum amount of useful reservoir storage was developed.

Irrigation Development

The analysis indicates that the total area in the basin is 2,338,300 acres. The acreage supplied from each river system is: 109,300 acres from the Red Deer; 1,173,000 acres from the Bow; 1,026,000 acres from the Oldman; and 30,000 acres from the South Saskatchewan. The acreage irrigated in this sub-scenario was distributed as indicated in Table 7.1. The additional reservoir storage is located as follows: 250,000 acre feet on the Red Deer river system, 3.1 million acre acre feet on the Bow system, and 3.9 million acre feet on the Oldman system.

The total area irrigated is increased by 898,690 acres over the Base Case. The economic performance criteria for irrigation would be satisfied at this level of development. The average maximum water supply deficit would be 16.9%. The annual net value added and the number of jobs created would be almost 60% greater than in the Base Case.

The cost of reservoir storage and rehabilitation and enlargement of headworks and district works required to support irrigation at this level of development is $5,061; an increase of $3,597 million over the Base Case.

Water Quantity

Compared to the Base Case, streamflow conditions for fish habitat in this sub-scenario would be somewhat worse in the Bow below Calgary, but somewhat improved in the lower Oldman.

Water quantity conditions for recreation in this sub-scenario are similar to the Base Case. There is a decline in the impact on boating on the Red Deer upstream from the City of Red Deer and on the Bow below Bassano Dam. Conditions for boating are improved on the South Saskatchewan and on the Oldman downstream from Lethbridge. Conditions for reservoir recreation are significantly changed on two reservoirs: Dickson Reservoir, where the impact during June increases from minor to major, and Keho Lake where there are major negative impacts in June and July as well as in August.

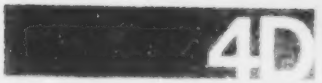
Water Quality

Water quality conditions at both the secondary and the advanced sewage treatment levels are comparable with those in the Base Case. The higher flows in the Oldman reduce or eliminate the impacts of un-ionized ammonia on fish habitat and the impacts of salts on municipal and industrial use. With advanced treatment, the impact of weeds and algae on contact recreation is reduced in the Oldman below Taber.

The costs for secondary and advanced sewage treatment are the same as for the Base Case.

Average Apportionment

On average, 57% of the flow of the South Saskatchewan system would pass into Saskatchewan; the percentage of flow passed by each river would be: Red Deer, 95%; Bow, 40%; Oldman, 48%.



4D - Maximum District Expansion/Equal Allocation/Additional Storage

Water Management

This sub-scenario illustrates the results that could be expected when the acreage that could be served by the enlargement of the works of existing districts is increased to the maximum possible amount, if the percentage of the flow of each river allocated to apportionment is set at Red Deer, 50%; Bow, 50%; Oldman, 50%; and additional storage is developed.

Irrigation Development

The area irrigated with water from the Oldman system is increased to 811,000 acres. An additional 1,330,000 acre feet of storage on the Oldman system is required to support irrigation at this level of development. The area irrigated with water from the Bow river system is increased to 874,400 acres. An additional 3,100,000 acre feet of storage on the Bow river system, the maximum amount of useful storage that can be developed with the water supply, is required to support irrigation at this level.

The total irrigated acreage in the basin is increased by 325,790 acres over the Base Case. The analysis indicates that irrigation at this level of development satisfies the economic performance crite-

ria. The average maximum water supply deficit is 18.9%. Both the annual net value added and the number of additional jobs are about 20% greater than in the Base Case.

The cost of reservoir storage and rehabilitation and enlargement of headworks and district works required is $3,585 million, an increase of $2,121 million over the Base Case.

Water Quantity

Streamflow conditions have a greater impact on coldwater fish habitat and a lesser impact on warmwater habitat than in the Base Case. The coldwater habitat in the Red Deer and in the Bow below Calgary, experience moderate impact. The impact on warmwater habitat in the Bow below Bassano Dam and in the Oldman below Lethbridge is reduced from severe to moderate.

Boating in this scenario is greatly improved over the Base Case while reservoir recreation suffers a dramatic decline. Conditions for boating improve on all major rivers. Flows in the Red Deer River are much better below Dinosaur Provincial Park, there are only minor negative impacts on boating in the Bow River below Bassano, the Oldman River downstream from Lethbridge has improved from major to minor impacts, and negative impacts on boating in the South Saskatchewan River are eliminated. Reservoir recreation, however, is affected by major negative impacts during July and August on St. Mary Reservoir and during the entire summer on Chestermere Lake, Lake McGregor, Travers Reservoir, and Keho Lake. In addition, moderate negative impacts occur on Waterton Reservoir throughout the summer, Dickson and St. Mary reservoirs during June, and Jensen Reservoir in August.

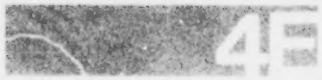
Water Quality

Water quality conditions are somewhat better than in the Base Case at both the secondary and advanced sewage treatment levels. This improvement is due to the higher flows in the Bow and Oldman during critical years. The impacts of unionized ammonia on fish habitat are reduced in the Bow, Oldman and South Saskatchewan. The impact of salts on irrigation is reduced in the Oldman below Taber and eliminated in the South Saskatchewan. The impacts of salts and sulphates on municipal use in the Oldman are eliminated.

The costs of secondary and advanced sewage treatment are the same as for the Base Case.

Average Apportionment

On average, 64% of the flow of the South Saskatchewan system passes into Saskatchewan; the percentage of flow passed by each river is: Red Deer, 95%; Bow, 53%; Oldman, 57%.



4E - Maximum Irrigation Expansion/Equal Allocation/Maximum Additional Storage

Water Management

This sub-scenario illustrates the maximum acreage that could be irrigated with the water supply of the South Saskatchewan river system, if the percentage of the flow of each river allocated to apportionment was set at: Red Deer, 50%; Bow, 50%; Oldman, 50%; and if the maximum amount of useful storage was developed.

Irrigation Development

The analysis indicates that the total area in the basin that could be irrigated is 2,148,500 acres. The acreage supplied from each river system is: 297,100 from the Red Deer; 847,400 from the Bow; 947,000 from the Oldman; and 30,000 from the South Saskatchewan. The irrigated acreage was distributed as shown in Table 7.1. The additional reservoir storage required is as follows; 340,000 acre feet on the Red Deer river system, 3,100,000 acre feet on the Bow system, and 3,900,000 acre feet on the Oldman system.

The irrigated area is increased by 708,890 acres over the Base Case. The economic performance criteria for irrigation would be satisfied at this level of development. The average maximum water supply deficit would be 14.6%. The annual net value added and the number of jobs created would increase by about 45% over the Base Case.

The cost of reservoir storage and rehabilitation and enlargement of headworks and district works required is $4,848 million, an increase of $3,384 million over the Base Case.

Water Quantity

Compared to the Base Case, streamflow conditions for fish habitat would be worse in the lower Red Deer and in the Bow below Calgary, but greatly improved in the lower Oldman.

As with 4D, this subscenario provides improvements over the Base Case for boating that are offset by much poorer conditions for reservoir recreation. The Bow and the South Saskatchewan rivers are almost always acceptable for boating. Conditions on the Oldman River downstream from Lethbridge improve from major to minor impacts. Overall, conditions for boating on the Red Deer River do not change. There is, however, an improvement in flows below the city of Red Deer that is nullified by a decline to major impacts below Dinosaur Provincial Park. The deterioration in reservoir recreation is severe with

major impacts occurring throughout the summer on seven reservoirs: Chestermere Lake, Chain Lakes, Lake McGregor, Travers Reservoir, Keho Lake, Jensen Reservoir and Ridge Reservoir. In addition, Dickson Reservoir experiences moderate negative impacts during June and St. Mary Reservoir experiences major impacts during June and July and a moderate impact during August.

Water Quality

With higher streamflow in the Bow and Oldman in critical years, water quality conditions at the secondary treatment level show some improvement in comparison with the Base Case. The impact of ammonia on fish habitat is reduced in the Bow, Oldman and South Saskatchewan. The impact of salts on irrigation are reduced in the Oldman below Taber and eliminated in the South Saskatchewan. The impacts of salts and sulphates on municipal water supply in the Oldman are eliminated. At the advanced treatment level, conditions are much improved over the Base Case. The only remaining problems are due to weeds and algae, which have a minor impact on irrigation and fish habitat in the Bow below Bassano Dam, and a major impact on contact recreation in the lower reaches of all rivers; ammonia and dissolved oxygen, which have an impact on fish habitat in the Bow below Bassano Dam; and salts, which have a minor impact on irrigation in the Oldman below Taber.

The costs of secondary and advanced sewage treatment are the same as for the Base Case.

Average Apportionment

On average, 58% of the flow of the South Saskatchewan system passes into Saskatchewan; the percentage of flow passed by each river is: Red Deer, 73%; Bow, 53%; Oldman, 52%.

Sub-Basin	Scenario 1					Scenario 2			
	A	B	C	D	E	A	B	C	D
Red Deer	228,430	228,430	228,430	228,430	228,430	228,430	228,430	228,430	228,430
Bow	296,770	296,770	296,770	296,770	296,770	296,770	296,770	296,770	296,770
Oldman	609,810	609,810	609,810	609,810	609,810	609,810	609,810	609,810	609,810
South Sask.	293,200	293,200	293,200	293,200	293,200	293,200	293,200	293,200	293,200
Little Bow[2]	11,400	11,400	11,400	11,400	214,400[1]	98,400	98,400	11,400	98,400
Special Areas[3]	–	–	–	–	–	59,300	128,500	155,700	247,100
Blackfoot Reserve (Bow)	–	–	–	–	–	10,000	10,000	–	10,000
Blood & Peigan Reserves (Oldman)	–	–	–	–	–	33,650	45,000	–	45,000
SSRB Total	1,439,610	1,439,610	1,439,610	1,439,610	1,642,610	1,629,560	1,710,110	1,595,310	1,828,710

Water Source	Scenario 1					Scenario 2			
	A	B	C	D	E	A	B	C	D
Red Deer	37,500	37,500	37,500	37,500	37,500	96,800	166,000	193,200	284,600
Bow	581,900	581,900	581,900	581,900	784,900[1]	678,900	678,900	581,900	678,900
Oldman	794,510	794,510	794,510	794,510	794,510	828,160	839,510	794,510	839,510
South Sask.	25,700	25,700	25,700	25,700	25,700	25,700	25,700	25,700	25,700
SSRB Total	1,439,610	1,439,610	1,439,610	1,439,610	1,642,610	1,629,560	1,710,110	1,595,310	1,828,710

Water Source	Scenario 1					Scenario 2			
	A	B	C	D	E	A	B	C	D
Red Deer	–	0	0	0	0	59,300	128,500	155,700	247,100
Bow	–	0	0	0	203,000[1]	97,000	97,000	0	97,000
Oldman	–	0	0	0	0	33,650	45,000	0	45,000
South Sask.	–	0	0	0	0	0	0	0	0
SSRB Total	–	0	0	0	203,000	189,950	270,500	155,700	389,100

TABLE 7.1
SSRBPP SCENARIOS
AREA IRRIGATED
A. By Sub-Basin (Acres)

Scenario 3			Scenario 4				
A	B	C	A	B	C	D	E
249,807	263,308	249,807	272,850	316,560	316,560	316,560	316,560
351,053	375,252	351,053	368,830	473,620	691,120	473,620	473,620
635,350	642,250	635,350	663,320	663,320	663,320	663,320	663,320
296,200	300,500	296,200	300,500	300,500	588,000	300,500	436,500
48,400	57,000	48,400	20,000	20,000	20,000	11,400	11,400
24,700	74,100	24,700	–	–	59,300	–	247,100
10,000	10,000	10,000	–	–	–	–	–
12,350	22,350	12,350	–	–	–	–	–
1,627,860	1,744,760	1,627,860	1,625,500	1,774,000	2,338,300	1,765,400	2,148,500

1. *includes 203,000 acres effluent irrigation*
2. *In Oldman Sub-Basin*
3. *In Red Deer Sub-Basin*

B. By Water Source (Acres)

Scenario 3			Scenario 4				
A	B	C	A	B	C	D	E
62,200	111,600	62,200	50,000	50,000	109,300	50,000	297,100
727,100	780,300	727,100	734,500	883,000	1,173,000	874,400	874,400
812,860	822,860	812,860	811,000	811,000	1,026,000	811,000	947,000
25,700	30,000	25,700	30,000	30,000	30,000	30,000	30,000
1,627,860	1,744,760	1,627,860	1,625,500	1,774,000	2,338,300	1,765,400	2,148,500

1. *includes 203,000 acres - effluent irrigation*

C. Increases From the Base Case (Acres) By Water Source

Scenario 3			Scenario 4				
A	B	C	A	B	C	D	E
24,700	74,100	24,700	12,500	12,500	71,800	12,500	250,800
145,200	198,400	145,200	152,600	301,100	591,100	292,500	292,500
18,350	28,350	18,350	16,490	16,490	231,490	16,490	152,490
0	4,300	0	4,300	4,300	4,300	4,300	4,300
188,250	305,150	188,250	185,890	334,390	898,690	325,790	708,890

1. *includes 203,000 acres - effluent irrigation*

River System	Base Case	Additions to Base Case							
	Scenario 1	Scenario 1				Scenario 2			
	A	B	C	D	E	A	B	C	D
Red Deer	155,000	0	0	0	0	0	810,000	0	575,000
Bow	1,467,000	0	0	0	0	0	0	0	560,000
Oldman	1,324,000[2]	0	0	0	0	0	90,000	0	2,240,000
South Sask.	0	0	0	0	0	0	0	0	0
SSRB Total	2,946,000	0	0	0	0	0	900,000	0	3,375,000

Source of water supply	Scenario 1					Scenario 2			
	A	B	C	D	E	A	B	C	D
Red Deer River	9	8	9	9	9	25	43	50	75
Bow River	151	132	142	147	192	168	168	145	171
Oldman River	213	134	162	193	211[3]	216	219	197	223
South Sask. River	8	8	8	8	8	8	8	8	8
SSRB Total	381	282	321	357	420	417	438	400	477

Source of water supply	Scenario 1					Scenario 2			
	A	B	C	D	E	A	B	C	D
Red Deer River	380	330	370	370	380	1,010	1,740	2,030	3,040
Bow River	6,170	5,320	5,770	5,980	7,820	6,840	6,840	5,900	6,960
Oldman River	8,670	5,260	6,460	7,790	8,600[3]	8,800	8,910	7,990	9,060
South Sask. River	340	340	330	330	340	340	340	340	340
SSRB Total	15,560	11,250	12,930	14,470	17,140	16,990	17,830	16,260	19,400

Additions to Base Case

Scenario 3			Scenario 4				
A	B	C	A	B	C	D	E
0	0	0	0	0	250,000	0	340,000
220,000	400,000	400,000	0	650,000	3,100,000	3,100,000	3,100,000
0	200,000	200,000	0	0	3,900,000	1,330,000	3,900,000
0	0	0	0	0	0	0	0
220,000	600,000	600,000	0	650,000	7,250,000	4,430,000	7,340,000

TABLE 7.2

RESERVOIR STORAGE[1] SSRBPP SCENARIOS BASE CASE (1A) AND ADDITIONS TO BASE CASE (Acre-Feet)

1. *over 4000 acre feet.*
2. *includes storage on Oldman, 400,000 acre feet; 40 mile, 70,000 acre ft., and Kehe Lake at 75,000 acre feet.*

Scenario 3			Scenario 4				
A	B	C	A	B	C	D	E
16	29	16	12	12	28	12	77
184	198	183	186	219	292	219	219
215	216	217	213	213	272	213	251
8	10	8	10	10	10	10	10
423	453	424	421	454	602	454	557

TABLE 7.3

NET VALUE ADDED AND EMPLOYMENT SSRBPP SCENARIOS

A-Net Value Added (million dollars[1])

Scenario 3			Scenario 4				
A	B	C	A	B	C	D	E
640	1,170	640	480	490	1,130	490	3,120
7,500	8,080	7,460	7,560	8,940	11,890	8,910	8,910
8,750	8,790	8,820	8,660[3]	8,640[3]	11,070	8,660	10,190
340	400	340	400	400	400	400	400
17,230	18,440	17,260	17,100	18,470	24,490	18,460	22,620

B-Employment (number of jobs[2])

1. *Net value added data for the sources of water supply have been rounded to the nearest million dollars.*
2. *Employment data for the sources of water supply have been rounded to the nearest ten jobs.*
3. *In these sub-scenarios, the amount of irrigated land served by the Oldman River is the same as the base case, but the economic results are slightly different. These differences are due to small changes from the base case in the way that apportionment is met and are not considered to be indicative of significant alterations in the economic impact of irrigation.*

Observations on the Scenarios

One of the principal purposes of the scenarios is to demonstrate the effects of the policy options and varying combinations of those options on water use and management. This was done by presenting the results that might be expected from different combinations of use priority, apportionment allocations and water management measures over a range of levels of water use. These results are illustrated on the scenario panels in terms of irrigation development performance and water quantity and quality conditions. Certain of the relationships between the policy options and the inherent trade-offs are apparent in each scenario. These and other relationships are discussed in some detail in the Scenario Report; some of the more apparent are noted here.

The direct trade-off between apportionment and storage is illustrated most clearly by comparison of sub-scenarios 4B and 4D. In both 4B and 4D, 811,000 acres are irrigated from the Oldman river system. In 4B, where only 30% of the flow of the Oldman is allocated for apportionment, no additional storage is required to irrigate this area. In 4D, where not less than 50% of the Oldman's flow goes to apportionment, 1.3 million acre feet of additional storage is required.

One of the more obvious trade-offs, that between storage and use, is apparent in a comparison of sub-scenarios 3A, 3B and 3C. The apportionment allocation is the same for all of these sub-scenarios. In 3B, the storage is increased over that in 3A and supports an increase in the irrigated acreage. In 3C, where the storage is increased by the same amount as in 3B, but the irrigated acreage is held at the same level as in 3A, there is a marginal improvement in the flow conditions for fish habitat.

The direct trade-off between the apportionment allocation for a river system and the acreage that can be irrigated from that river system is illustrated by comparison of sub-scenarios 4C and 4E. The additional storage on the Bow and Oldman systems is the same in each of these sub-scenarios. In 4C, where only 30% of the flow of each of these rivers is allocated to apportionment, the Bow and Oldman are able to support 2.2 million acres of irrigation. In 4D, however, with 50% of their flows allocated to apportionment, the Bow and Oldman are able to support only 1.7 million acres – about 23% fewer acres than in 4C. This relationship is also apparent in 2C, where with equal apportionment allocation the Bow and Oldman cannot support the acreage irrigated in 1A, the Base Case, where apportionment allocations are not specified.

Comparison of sub-scenarios 1A and 2A reveals the effect of an increase in the apportionment flow allocation on instream flow conditions. In 1A, the Base Case, where no apportionment allocation is specified, the critical year contribution from the Oldman is only 13% and the impacts on fish habitat are severe. In 2A, where the apportionment allocation on the Oldman is 40%, the impact of flows on fish habitat downstream from Lethbridge are moderate. At the same time, a greater acreage is irrigated from the Oldman with no increase in storage, and, although the average maximum water supply deficit is about four times what it was in 1A, the economic performance criteria for irrigation are satisfied.

Comparison of sub-scenarios 1A and 1B illustrates the relationship between streamflow and water quality conditions. In 1B, fish habitat has priority over irrigation and in comparison to 1A, substantially greater percentages of the flow of the Bow and Oldman pass downstream during low flow years. Due to the diluting effect of these greater streamflows, water quality conditions in 1B, particularly in the Oldman, are much improved over those in 1A. The improved instream conditions in 1B are realized at the expense of irrigation, which fails in this sub-scenario. Similar relationships are apparent in comparing 1A with 1C or 1D where recreation has priority over irrigation.

In sub-scenarios 1C and 1D, where recreation is the priority water user, streamflow conditions compared to the Base Case are improved for boating. However, conditions for fish habitat, and thus for recreational fishing, are not improved in the Bow and Oldman and are somewhat worse in the lower Red Deer. This suggests that there is a degree of conflict between requirements for these two recreational uses.

Although not discernible from the information presented on the scenario panels, the annual net value added for each acre of land irrigated in addition to the Base Case increases in proportion to the percentage of the additional acreage located in agro-climatic zones A_1 and A_2. For example, irrigation in sub-scenarios 4B and 4C experiences similar water supply deficits, however, the additional net value added per additional acre is $223 in 4B, where 51% of the additional acreage is in agro-climatic zones A_1 and A_2, but $248 in 4C, where 82% of the addi-

tional acreage is in A_1 and A_2.

Comparison of sub-scenarios 2D and 4D, suggests that, from an economic perspective, there is little to choose between expanding irrigation in areas served by existing irrigation districts or developing irrigation in other regions. There are somewhat more acres irrigated in 2D, which features regional development, than in 4D, which features district expansion. At 64%, 2D has a greater percentage of expansion acreage in agro-climatic zones A_1 and A_2 than does 4D at 52%. Sub-scenario 2D also experiences slightly lesser water supply deficits than does 4D. These factors together account for the somewhat greater net value added in 2D. Although the storage requirements and the storage costs are greater in 4D, the total costs of irrigation development in the two sub-scenarios are comparable, due to the greater costs for headworks and district works required to develop new areas in 2D. However, when a regional expansion sub-scenario, 2A, is compared with an existing district expansion sub-scenario, 4A, with irrigation development held at a level that does not require additional storage, a different picture emerges. The acreage irrigated and the net value added are comparable in these sub-scenarios, but the substantially greater cost for headworks and district works in 2A suggests that where no additional storage is required it is less costly to expand existing districts.

The levels of development illustrated in the scenarios have a significant impact on water quality. Advanced treatment of the sewage effluent of the major urban centres results in a general improvement in water quality conditions downstream from these centres. This is evident in all scenarios. Sub-scenarios 1A and 1E illustrate the effects on water quality conditions of land disposal compared to advanced treatment of Calgary and Lethbridge sewage effluent. In this comparison, land disposal appears to be only marginally more effective than advanced treatment in improving water quality. The cost of the Calgary effluent irrigation scheme illustrated in 1E is considerably greater than the cost of advanced treatment; however, less expensive schemes may be possible. The benefits accruing from effluent irrigation are substantial. The social impacts of keeping the effluent out of the rivers or of using it for irrigation were not considered in this analysis.

Only in sub-scenarios 4C and 4E, with the maximum possible storage, are the long-term average flows to Saskatchewan less than 60%. For most sub-scenarios the percentage of flow passed to Saskatchewan ranges between 65% and 70%, compared to the 1969-1983 average of 83%. As illustrated in 4C, with conventional irrigation practice and the performance criteria applied in this analysis, the maximum amount of land that can be irrigated with the water supply of the South Saskatchewan river system is 2.3 million acres.

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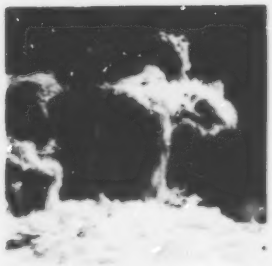
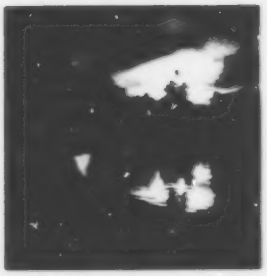
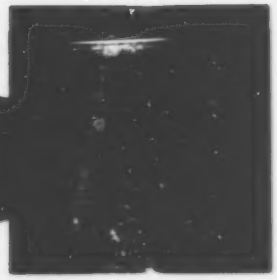
Choices About The Future

This report offers no conclusions or recommendations about the future direction that water use and management in the South Saskatchewan River Basin should take. The information contained in this and the supporting reports represents the completion of extensive and intensive efforts by Alberta Environment staff and others. Important public input has been received, but the major task for readers of this report is just beginning.







What use do Albertans wish to make of the water in the river system in future years? An awareness of the South Saskatchewan River system and the intricacies of the use and management of the water in that system is essential to any effective response to this basic question. One major goal of this **Summary Report** is to provide a basic understanding of how this system works to as wide an audience as possible. It is the hope and intention of Alberta Environment that members of the public from all walks of life and all parts of the basin will, by studying this report, be enabled to respond effectively to this question.

Experts in many facets of water use and management will provide their opinions about the future of the South Saskatchewan River Basin. These opinions will be valuable in assessing the options, for these experts understand how various aspects of the system function and interrelate.

The citizens of this province and residents of this basin can also offer expert advice. Their expertise relates especially to their knowledge about what the South Saskatchewan's water means to them, to their experience of how water use and management in the basin have affected their lives, and to their hopes for continued benefits from this resource. Their informed consideration and response is essential to the full and effective consideration of the questions that were posed in Chapter 1:

1. How is the supply of water to be allocated among uses?
2. What are the priorities among the options for water management?
3. How much water will each of the three major rivers contribute to apportionment?

This report provides a concise description of several possible strategies that illustrate a variety of directions for water use and management and the trade-offs among them. Armed with this basic information about water use and management and the description of a variety of possible future directions, and with the more detailed background information that is available, the public should be able to enter into a serious and constructive discussion on the issues. The specific interests of various groups and regions may in certain ways conflict, but as legitimate interests they all represent important elements of a common future. It is hoped, therefore, that all participants will approach this process not only with the intention of representing their own interests, but also with a readiness to listen to those of others, realizing that the future quality of life in the South Saskatchewan River Basin will depend on achieving a mix of economic, social, environmental and cultural objectives in all parts of the basin.

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